LAKE STATES FOREST EXPERIMENT STATION

Technical Notes, Nos. 1 - 400

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

St. Paul 1, Minnesota

M. B. DICKERMAN, Director

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SUBJECT MATTER INDEX

TECHNICAL NOTES 1-300

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LAKE STATES FOREST EXPERIMENT STATION

U. S. Department of Agriculture - Forest Service
University Farm, St. Paul 1, Minnesota

M. B. DICKERMAN, DIRECTOR

LAKE STATES FOREST EXPERIMENT STATION

TECHNICAL NOTES, Nos. 1 - 300

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LAKE STATES FOREST EXPERIMENT STATION

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U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

St. Paul 1, Minnesota

M. B. DICKERMAN, Director

LAKE STATES FOREST EXPERIMENT STATION

TECHNICAL NOTES, Nos. 301 - 400

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LAKE STATES FOREST EXPERIMENT STATION

Behavior of White, Norway and Jack Pine Seeds

The Lake States Forest Experiment Station is undertaking tests which will throw more light on the proper conditions for storage and vigorous germination of pine seeds, both as regards the condition of the seeds and of the storage place. Since 1912 the seed used by the National Forests in the Lake States has been tested for germinability at the Rocky Mountain Forest Experiment Station. Through the courtesy of the Acting Director, C. G. Bates of the Lake States Station has been permitted to review these tests as a basis for any new work to be done.

Germination Characteristics:

All germination tests have been in sand, with the temperatures reaching 57° and 77° each 24 hours, as nearly as possible. They have been run for various periods, some as few as 25 days, but most for 40-60 days.

Species	Avg. No. Seeds per lb.	No. Tests Made	No. Seeds Tested	Avg. Total Germ'n	Peak of Germination Reached: Days from Sowing	Peak of Germination Reached: Proportion of Total Germination Before Peak
White P.	28,000	22	11,500	17.9%	20	36%
Norway P.	61,000	32	17,000	75.1%	15	48%
Jack P.	127,000	66	33,000	57.8%	12	36%

The germination of white pine is by no means complete at 50 days, but is progressing very slowly. The tests of this species in sand, under one set of conditions, tell us very little of actual value, as white pine is known often to extend its germination over a year or more. Norway pine germination is practically completed at 40 days; Jack pine, although beginning more quickly, is inclined to spread its germination over a much longer period. Probably only about 90% of the total possible germination has appeared at the end of 50 days, and in nurseries no doubt a few of the laggards hold over until the second season. Two out of three tests of Wisconsin Jack pine seed showed much better germination, and all were heavier than the average, which was made up almost wholly of collections from the Minnesota National Forest. The third lot was one which had evidently been injured by crude treatment.

Keeping Quality:

Although the conditions of storage were variable, and probably in no case better than that of a moderately insulated room, it is interesting to observe that seeds of a given year's collection came up for testing repeatedly through five or six years. The comparisons, while lacking precision, seem to indicate that there is practically no deterioration in Norway pine up to three or four years, and, in fact, one sample of the 1910 collection, when tested in 1920, had dropped only from 90% to 82% germination. White pine deteriorates rapidly within the first two or three years, and within five or six years is likely to be a total loss. Jack pine shows appreciable deterioration in a year or two, and in five years is likely to have lost half its value. It is thus about intermediate between white and Norway in keeping qualities.

May, 1928.

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LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Abandoned Fields are Best Sites for Forest Planting

Norway pine, white pine, jack pine, Scotch pine, and Norway spruce grow exceptionally well on abandoned fields or cultivated soils. It makes little difference whether the fields were cultivated and abandoned years ago or whether the soil is cultivated just before and after the planting of the trees, their growth, at least for the first twenty years after planting is strikingly more rapid than the growth of the same species on the same soils in their natural condition. Norway and white pine planted on old fields averaged over seven feet high when ten years old, while they were only two to three feet high on wild lands. Even the white pine plantations on excellent loam soils were only about five feet high, as compared with seven feet, on the poor sandy lands which had been cultivated and abandoned. Jack pine averaged nine feet in ten years on the cultivated soils and only six to seven feet on the wild lands. Apparently, therefore, the growth of planted trees on old fields is one and one-half to two times as great as on uncultivated soils. This advantage, however, may not continue to be as great relatively as the trees grow older. It appears, however, that forest plantations on old fields will be merchantable five or ten years sooner than the same crops on wild land.

While it cannot be proved that the cost of cultivating a forest plantation for two or three years before and after planting is justified in order to obtain the increased growth, it is certain that abandoned fields on almost any soil are particularly favorable sites for planting forest trees. Anyone who owns or can acquire cheaply such lands is likely to find forest planting a profitable method for their utilization.

May, 1928.

*Maintained by the U.S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION

Jack Pine Yields per Acre

in Michigan, Minnesota and Wisconsin

Age	Height average dominant trees	Number trees 4" and over	Average diameter stand 4" and over	Number of cords	Board feet and cords* International Rule		Board Feet and cords* Scribner Dec.C. Rule	
Years	Feet		Inches		Bd. ft.	Cds.	Bd. ft.	Cds
			GOOD SITE					
30	44	790	5.3	26	3000	16	1000	22
40	56	555	6.6	37	9500	12	5500	20
50	66	395	7.9	43	16000	7	11500	14
60	75	300	9.1	46	20500	5	15500	10
70	81	245	10.1	48	24000	4	18000	9
80	86	210	11.0	50	26000	4	20000	9
			MEDIUM SITE					
30	35	815	4.6	17	1000	14	--	--
40	45	730	5.4	27	3500	16	1000	22
50	53	555	6.4	33	7500	11	4500	19
60	60	430	7.2	36	11500	8	7500	16
70	65	360	8.0	38	15000	6	10500	12
80	69	310	8.6	40	16500	5	12000	10
			POOR SITE					
30	27	655	4.2	8	500	7	--	--
40	34	760	4.7	16	1000	13	--	--
50	40	690	5.3	22	2500	14	500	19
60	45	580	6.0	25	4500	11	2000	18
70	49	490	6.5	27	6500	9	3500	16
80	52	430	7.0	28	8000	8	5000	14

*These cords are obtained from small trees and tops of larger trees and are in addition to the board feet shown.

Sites based on height of dominant trees.

May 1928.

LAKE STATES FOREST EXPERIMENT STATION*

Growth of Northern White Cedar in Northern Wisconsin and Minnesota

The slow growth of northern white cedar in northern Wisconsin and Minnesota under existing natural conditions was confirmed by recent counts and measurements of 40 trees. In view of the decreasing supply and the continued demand for poles and other cedar products, it seems worth while to make even these meager notes on growth available.

The growth on mineral soils above the swamp levels is distinctly better than the growth on the peat of the swamps. The difference is striking, and may be illustrated by the time required to produce a 20 foot pole. On mineral soil, from 110 to 160 years are required, and in the swamps, from 170 to 210 years. The minimum, average, and maximum ages for trees of different diameters are indicated in the following tabulation:

Diameter at 4½ ft. Inches	Mineral Soil Minimum	Mineral Soil Average	Mineral Soil Maximum	Peat Minimum	Peat Average	Peat Maximum
	Age in Years					
4	40	52	60	60	77	100
5	45	65	85	80	98	130
6	60	78	110	95	120	175
7	70	91	125	115	140	175
8	80	105	130	130	160	180
9	100	117	145	150	183	210
10	105	130	160	170	204	220

The figures for peat soils correspond quite well with those for cedar in Northern Minnesota given in Table 4 of Farmers' Bulletin Number 1177, "Care and Improvement of the Farm Woods."

Cedar will usually have to be 8 inches or over in diameter to produce a 20 foot pole and 9 inches or better to produce ties.

May, 1928.

*Maintained by the U.S.Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA
No. 5

Climatic Seed Sources for Norway Pine

Norway pine will figure very largely in reforestation in the Lake States. It is of the utmost importance to plant only stock thoroughly adapted to the climate of the planting site. The selection of the right seed-source may mean the difference between successful and unprofitable forest planting. The Lake States Forest Experiment Station has, therefore, undertaken a study of the effect of different seed sources. But experiments and experience elsewhere already point the way to intelligent forestry practice. For example, in Sweden it has been proven that Scotch pine seed must be used very close to the place where it is grown. If the mean summer temperature of the planting site varies by so much as 1 degree C (1.8 degree F.), from that of the seed source, results may be expected to be only 65% as good as if "home-grown" seed had been used. What may this mean in the case of Norway pine?

Norway pine in the Lake States grows under summer temperatures varying from 57 degrees to 66 degrees F. The lines of equal summer temperatures do not run due east and west, but on account of the influence of the Great Lakes tend to swing far southward in the eastern portion of this territory. Thus the line indicating a summer average of 60 degrees follows closely the southern and western shores of Lake Superior to Two Harbors, Minnesota, and then turns straight north to the Canadian boundary. (Minnesota from Lake County eastward is the only territory with temperatures appreciably below 60 degrees.) Summer temperatures of about 63 degrees are found at the western boundary of Minnesota in Marshall County, over quite an extensive territory around Red Lake, Cass Lake, Leech Lake and Mille Lacs, across Wisconsin from Burnett County to Marinette and thence nearly due east across Michigan. The 66-degree line strikes through Traverse, Kandiyohi and Chisago counties in Minnesota, Pierce, Sauk, and (north of Lake Winnebago) Sheboygan counties in Wisconsin and Muskegon, Bay and St. Clair counties in Michigan. Latitude alone does not indicate localities of similar temperatures.

The Chippewa National Forest at Cass Lake, Minnesota has long been a source of large supplies of Norway pine seed. Since its mean summer temperature of 63-64 degrees is nearly average for the range of Norway pine, it may represent nearly the optimum for the development of the species. This does not mean, however, that Cass Lake seed is the best to use in either the cooler or warmer portions of the Norway pine territory, but on the contrary, its use should be restricted to the middle portion of the range which has the same moderate temperatures. Northeastern Minnesota and the Upper Peninsula of Michigan represent a territory by themselves. Interchange of seed within this territory is proper and legitimate, especially as both sections are made somewhat humid by proximity to Lake Superior, but the use of this northern seed in the central or southern portion of the Norway pine belt is questionable practice. Likewise, the southern part of the range, approaching the 66-degree line, needs seed sources of its own, especially if Norway pine is to be planted further south than it grew naturally. These considerations call for intelligence and cooperation to insure the use of seed within its proper zone. Every large reforestation enterprise should develop its own seed supply locally. The same principles, of course, apply to other species as well. The indiscriminate exchange of forest tree seeds should be discouraged. Summer temperature map for the Lake States may be had on request.

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

October, 1928

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION

U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE

No. 5

UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Growth of Northern Hardwoods After Partial Cutting

The question uppermost in the mind of those who consider selective cutting of northern hardwoods in place of the old clean cutting is, how fast do the trees left uncut, grow? A preliminary study of growth after partial cutting conducted in cooperation with the University of Wisconsin on 20 different areas reveals, as far as the computations were compiled, some interesting facts. The final results may be somewhat modified. In case of cuttings, where nearly 85 percent of the original merchantable stand has been cut, the annual growth per acre per year ranges from 100 to 175 board feet. A summary for nine plots give these results:

Growth Per Acre After Partial Cutting

Number of years since first cutting	Original stand	Amount cut 25 years ago	Amount of timber left 25 years ago	Present stand	Growth during past 25 years	Average annual growth per acre per year
Years	Feet Board Measure					
25	7,016	5,970	1,046	4,196	3,150	126

The cutting on these nine plots was very severe, leaving only 15 percent of the merchantable stand. If 50 percent or more of the original stand were left, the growth per acre would be nearer 200 board feet than 126. If a cut of 3,000 to 4,000 board feet is practicable, successive cuts, under selective logging, could be expected at intervals of 15 to 25 years. On areas clean cut 100 years would be required to grow maple and hemlock to a minimum saw log size of 12 inches diameter breast high and produce a stand of about 4,000 board feet per acre. This means an annual growth of 40 board feet. A clean cut area, not burned in 20 years, will have, as a general rule, a stand of young timber averaging about 4 inches in diameter breast high ($4\frac{1}{2}$ feet from ground).

Hemlock and sugar maple make the greatest diameter growth in partially-cut hardwood stands. Yellow birch does not respond so well. The rate in diameter growth following a partial cutting is usually about twice as great as that for the same period prior to cutting. The rate appears to be in direct ratio to the severity of the cutting. Diameter growth is most rapid on areas cut heavily. Growth measurements taken for 395 hemlock trees show an average diameter growth at $4\frac{1}{2}$ feet from the ground of 1.8 inches for a period of 20 years prior to partial cutting. The growth for a similar period following cutting was 3.4 inches. The average diameter growth for the three principal species of the hemlock-hardwood forest type is shown below.

Growth in Diameter Before and After Cutting

Species	Number of trees	Diameter $4\frac{1}{2}$ feet from ground	Average diameter growth in inches: 20 years before cutting	Average diameter growth in inches: 20 years after cutting
		Inches		
Hemlock	395	12.5	1.8	3.4
Sugar maple	648	14.7	2.0	3.2
Yellow birch	200	14.4	1.7	2.6

Octo

LAKE STATES FOREST EXPERIMENT STATION

The Forest Seed Crop of 1928.

The season of 1928 has been, on the whole, a fair one for the production and collection of forest tree seeds in the Lake States. The preceding year was, of course, a very good one for the pines, especially for Norway pine, and as was to have been expected, Norway and jack pines, at least, have had very light crops in 1928. In fact with Norway pine in most localities in the Lake States only an occasional tree has had any crop at all, but it is surprising how heavily this occasional tree did bear cones, after having produced also in 1927. In the case of white pine most trees bore heavily, although throughout the region the crop was spotty, with some localities producing no seed at all. The crop of white spruce seed has been exceptionally heavy almost everywhere.

Many other species, such as white and red cedar, black spruce, hard maple, basswood, black locust, and the nut-bearing oaks, hickories, and walnuts, have borne moderately to heavily in 1928, in many places within the region. It must on the whole, be called a "mast year" for forest trees which ripen their seed in a single year. Without doubt this must be ascribed in part to the abundance of moisture throughout the season, but also in part to a spring which, while cold, advanced steadily without any serious setbacks.

With the object in view of supplying information in time to be of assistance in seed-collecting, the Lake States Forest Experiment Station would like to initiate a much more comprehensive survey of the successful annual forest seed crops of this region than is possible through the observations of the few members of its own staff. Even, however, if this resulted only in the maintenance of a continuous record for the more important species, the cooperative effort would be worth while in showing what is to be expected, and perhaps in explaining the reasons for the large variations in seed-production. Those who are in a position to cooperate will assist us greatly by volunteering their help, and by indicating on what species, and in what localities they will be able to make observations from year to year. We shall then be glad to submit plans for the handling of this information with the least effort, and to set up certain standards as guides for reporting.

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October 1928

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Technical Note No. 8

Amount of Solid Wood per Cord of Sticks of Different Diameters

The cutting of hard maple and yellow birch on the experimental forest of the Upper Peninsula Branch Station (near Rus
e, Michigan), afforded an opportunity to determine: 1) the amount of solid wood per standard cord of sticks of different diameters, from small to large; 2) the variation in solid content of wood per standard cord, depending upon the diameter of the stick.

The cordwood material (hard maple) which was cut for hardwood distillation plant was made up of billets 4.3 feet long, cut from tops of trees and from so-called "chemical" logs. The wood was piled in stacks 4.3 feet high, allowing .3 feet for shrinkage. For this reason, a cord contained more wood than a standard cord, and 100 such cords were, on the average, equal to 110 standard cords (4 x 4 x 8 feet).

The average amount of solid wood per standard cord, irrespective of the diameter of the stick, was found to be equal to 80 cubic feet <u>with</u> bark, and 65 cubic feet <u>without</u> bark.

The amount of solid wood varied with the diameter of the sticks as follows:

Middle diameter of sticks outside bark	Number of sticks	Number of cubic feet: With bark	Number of cubic feet: Without bark
Inches		Per standard cord	
5	93	50	39
6	75	59	45
7	61	66	52
8	50	70	56
9	42	74	60
10	35	77	62
11	30	80	64
12	26	82	66
14	20	84	69
16	15	86	71
18	12	87	72
20	10	88	73

These figures are for round sticks. For sticks 10 inches and larger in diameter, when split, the solid contents should be reduced by 5 cubic feet. If the cord is made up of only large butts (more than 16 inches in diameter), the solid contents should be reduced by 7 cubic feet.

October 1928

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 9

What Happens to Millions of Little Trees in a Virgin Hardwood Forest

About every other year a sugar maple forest is almost literally covered in the fall with a mat of maple seed. Early next spring the forest floor is carpeted with maple seedlings. In some of the densest spots they run at the rate of over a million seedlings per acre. The life of these young trees, however, is very short. During the second year of their life hardly one-fifth of them survive, and only 3 per cent reach a height of over 5 feet and a diameter above 1/2 inch. Many causes contribute to this high mortality - severe competition, heavy shade, drought, frost, and others - but these are the subject of another study. The story of actual survival is told in the counts made on eight permanent sample plots in a virgin maple forest in the Upper Peninsula of Michigan near Marquette.

Age of seedlings	Sugar Maple		Other Trees**		Shrubs***	
	1927	1928	1927	1928	1927	1928
	NUMBER OF SEEDLINGS PER ACRE					
1-year	18,012	50*	-	-	-	75
2-year		3,600	-	-	-	-
3 - 8 yr.	6,113	4,862	187	163	2,543	2,025
9 - 15	5,212	4,362	88	50	162	188
16 - 20	1,550	1,550	25	25	112	162
21 - 25	588	588	37	62	75	38
Total	31,475	15,012	337	300	2,912	2,488

*Poor seed year.
**Includes elm, basswood, ironwood, and balsam.
***Includes hazel, yew, chokecherry, elderberry and currant.

A sugar maple forest needs no planting by man. Nature provides abundantly for its regrowth. What man needs is knowledge and skill of how to bring through the young seedlings to maturity.

March 1929

LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM, St. Paul, Minnesota

Growth in Swamps Before and After Drainage

The growth of trees was studied last summer along the outlet ditches in 26 swamps in Minnesota and 10 drainage districts in Wisconsin, in cooperation with the Universities of Minnesota and Wisconsin respectively. The results are given in the table below:

Species	Growing* conditions	Growth per acre per year before and after drainage.				
		Before	After	Before	After	Percent increase**
		Cubic	feet	Cords		
Black spruce	Poor	10.8	25.8	.14	.34	139
	Fair	23.6	48.0	.29	.58	103
	Good	23.2	65.0	.29	.81	180
	Excellent	27.6	41.7	.53	.50	51
Tamarack	Poor	6.6	13.0	.08	.16	100
	Fair	10.8	40.1	.14	.52	271
	Good	37.0	65.0	.44	.81	76
	Excellent	34.9	34.9	.44	.44	0
Cedar	Fair	16.5	35.1	.16	.39	113
	Good	30.3	68.9	.36	.85	126
	Excellent	52.7	93.8	.63	1.06	78
Hardwoods	Excellent	22.0	146.0	.33	1.75	563

*Growing conditions based on comparative height of largest trees in each stand at age of 100 years.

**Based on growth in cubic feet.

This growth was observed close to the ditches. Back from the ditch the increased growth falls off sharply, generally disappearing within 150 to 400 feet of the ditch bank.

This is the effect on timber growth of outlet ditches, the effectiveness of many of which has been reduced since their construction 10 to 15 years ago. The growth figures are indicative of what proper drainage can accomplish over wide areas.

March 1929.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 11

Returns from Selective Logging

As the commercial practice of selective logging in the hardwood forests of the Lake States gains momentum, other timber operators are considering its adoption. Many are still held back, however, by certain economic fears, chiefly the fear that it will prove more costly than clear cutting. Five separate experimental cuttings at the Upper Peninsula Branch Station near Marquette, Michigan, indicate that selective logging actually yields higher net returns per thousand board feet cut than clear cutting.

Kind of cutting	Volume cut per acre	Percentage of original volume cut	Selling price of logs cut (f.o.b. cars)	Total operating cost (from stump to loaded car)	Net returns*
	Bd.ft.	Percent	Per M	Per M	Per M
Selective 22" diameter limit 20 acres	2,250	35.4	$31.62	$12.05	$19.57
Selective 20" diameter limit 10 acres	2,475	52.1	30.10	12.81	17.29
Selective 19" diameter limit 10 acres	4,895	57.7	30.62	11.33	19.29
Selective 12" diameter limit 5 acres	7,297	92.3	29.19	11.33	17.86
Clear cutting 6" diameter limit 5 acres	10,740	100.0	28.97	11.33	17.64

*Includes both stumpage and profit.

The value of logs from the selective cuttings averages $1.81 per M higher than the value of logs from the clear cutting, and is also well above the prevailing regional log prices. The cost of logging compares very favorably with that of any commercial clear cutting operation.

These figures are the direct answer to the critical question, "Will it pay?" that is so often the stumbling block in forestry. Selective logging does pay, not only a hundred years hence, but right now.

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

March 1929.

LAKE STATES FOREST EXPERIMENT STATION
University Farm, St. Paul, Minnesota

Germination Tests of Tree Seeds

This Station is now in a position to make a limited number of germination tests of seed of the coniferous trees of the Lake States, when by so doing it may be helpful to public forestry agencies or in promoting the study of seed. Commercial seed samples cannot be taken on at the present time, nor is the Station as yet equipped to handle the seeds of the hardwood or broad-leaved trees, some of which require special conditions.

In order that the Station may gain information about seed behavior, while performing this service for others, seed samples submitted for testing should always bear the following information on an enclosed label, and such other information as in the opinion of the sender, may explain the behavior of the seed:

Name and address of sender.
Species of seed.
Number to identify sample. (Put same number on your stock of seed.)
Time of collection. Place of collection.
Extracting method and temperatures employed.
Should unused residue of seed be returned to sender?

At least sixty days should be allowed for making germination tests, but results will be returned sooner if possible.

A germination test can be no more accurate than is the taking of the sample. Senders of samples should use the utmost care to see that they are representative of the lots of seed on which information is desired. In general, this means taking the sample from all parts of the stock of seed. Avoid, especially, taking the sample from the top of a sack or can, or from the edge of a pile. The larger the sample is, the less likely it is to be abnormal. Because of sampling errors, the Station can assume responsibility only for the showing made by the sample as received.

Samples will not be accepted for testing unless they contain at least 2,500 seeds, and residues remaining from samples of this size will not be returned, but may be retained by the Station for further study. If larger samples are sent, residues will be returned when so requested.

The sender will, at the close of the germination test, be supplied with information showing the weight of a small sample "rough-cleaned" (that is, in the condition in which received), the weight of the same sample after removal of everything except possibly germinable seeds, number of seeds in the sample and the germination percentage of the seeds. From these may be computed the "purity" percentage and the number of germinable seeds per pound both rough and perfectly clean. The moisture content of the clean seed will usually be given also.

Wrap seed samples to avoid crushing, and mail to the Station.

March 1929

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 13

What Causes "Birds-Eye" Maple"

In the past, the peculiar grain of wood in sugar maple, known as "birds-eyes" has been speculatively ascribed to the "pecks" of sap-suckers and woodpeckers, to disease, to "adventitious" buds in the inner bark, and many other things. Recent observations show that whatever may be the direct cause, birds-eye maple generally is associated with slow growth, with formation of narrow rings, which so often occurs when the trees of the natural forest are crowded and "suppressed" by lack of light.

The Lake States Forest Experiment Station, in cooperation with the Forest Products Laboratory of the U. S. Forest Service, began in 1928 an attempt to determine whether trees showing the valuable and beautiful marking known as birds-eye could be "grown to order," and particularly whether the characteristic was hereditary, that is, could be had by growing young trees from the seeds of old trees strongly marked with birds-eyes. While searching in the forest for well-marked specimens from which seeds or cuttings could be taken, it was observed that typical <u>old</u> birds-eye maples cut for their lumber, no matter how vigorous their later growth, had in early life generally been of very slow growth. It was also observed that <u>young</u> trees whose wood contained minute depressions which might ultimately develop into typical birds-eyes, were usually in this unthrifty condition, and were seldom straight and vigorous. Whatever, therefore, may be the outcome of the attempt to breed and grow trees with this special characteristic, it seems probable that the conditions under which the young trees develop will have considerable influence on the formation of birds-eyes. At least this "hunch" will be taken into consideration in the formation of special "birds-eye maple" plantations.

March 1929

LAKE STATES FOREST EXPERIMENT STATION
University Farm, St. Paul, Minnesota

Interception of Rainfall by the Forest

Measurements made at two stations in northeastern Wisconsin the spring and fall of 1928 indicate that forest cover prevents about 20 percent of the total rainfall from reaching the ground. This varies, however, with the character and density of the forest canopy and the amount of rain that falls. In the case of broad-leaf trees, for example, a larger percent of the total precipitation was intercepted than in the case of jack pine, and heavy rains were found to be more effective in reaching the forest floor than light rains.

The amount of rain reaching the ground in the open and in the forest tells the story.

	Jack Pine Station			Hardwood-Hemlock Station		
	Spring	Fall	Spring & Fall	Spring	Fall	Spring & Fall
	Inches			Inches		
In the open	3.36	5.19	8.55	2.48	5.73	8.21
In the forest	2.71	4.00	6.71	1.87	4.84	6.71

Thus, only 78.5 percent of the total rainfall reached the ground in the jack pine forest and 81.8 percent in the hardwood-hemlock forest. In other words, about 20percent of the total rainfall was intercepted by the forest canopy.

In the hardwood-hemlock forest 75.4 percent of the total rainfall reached the ground in the spring and 84.2 in the fall. This was due to the fact that in the spring the trees were in leaf while in the fall the leaves were down.

The effect of intensity of precipitation on the amount that reaches the ground in the forest is shown by the following measurements.

Intensity of precipitation in the open	Amount reaching ground in the forest: Inches	Amount reaching ground in the forest: Percent	Number of cases averaged
.037	.020	54.5	24
.152	.087	73.6	6
.244	.192	79.5	7
.385	.335	87.0	2
.463	.387	83.5	3
.575	.475	82.6	2
.625	.530	84.8	2
.730	.610	83.6	1
1.070	.910	85.0	1
1.420	1.260	88.7	1
1.700	1.530	90.3	2

These data, while too meager to be conclusive, indicate that the effectiveness of precipitation in penetrating forest cover increases rapidly as the amount increases up to about .3 inch, then more slowly. Roughly, .05 inch of rain is only 60 percent effective, .1 inch - 70 percent, and .3 inch, 80 percent. Beyond this the increase appears to be about 2/3 of 1 percent for each .1 inch increase in precipitation. This is accounted for by the fact that the amount of rainfall retained by the leaf canopy is limited.

August 1929

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 15

Storage of Norway Pine Seed

While Norway pine seed is easily "kept" and probably retains its vitality as long as any evergreen seed if given a fair chance, the high cost of the seed, the limited supplies, and infrequent crops of this species makes it imperative that available supplies be conserved as far as possible through storage which will not permit rapid deterioration.

The general principles of storage for seeds which are best kept in a dry state, are well understood. They should be kept away from the air, and they should be kept reasonably cool, frequent changes of temperature being especially avoided. These principles have resulted in the rather general practice in this country of storing pine seeds in galvanized iron cans of large capacity, with small mouths which are closed by screw or friction caps. Such cans can be stored in cool cellars with practically no risk of the seed being affected by the moistness of the surroundings.

One point which has not been made clear by previous storage tests is the best degree of dryness for the seed at the time of storage, assuming that there is no opportunity for this to change after storage. It is a well-known fact that if seed has too much of its "green moisture" at the time of storage, it will later "sweat," and quick spoiling will result. That storage in moisture-proof containers has usually been successful, is due largely to the fact that excessive moisture is removed when pine cones are opened by artificial heat. Nevertheless it is possible for too much or too little moisture to remain in the seeds after such treatment.

The storage test on Norway pine seed at the Lake States Station is only slightly over a year old and is incomplete in several respects. These original tests will be continued for a number of years, and other supplies of seed will be placed in storage, but it is thought that the results already obtained may be of considerable interest. These results at one year, subject to the usual variations which arise from treating only small numbers of seeds, do not speak for what may occur after longer periods of storage.

Briefly, the germination tests at the end of a year show that seed stored in a cool root-cellar retained its vitality slightly better than that which was kept at a constant temperature very close to 32 degrees F., and germinated twice as well as that stored under "warehouse" conditions, when the temperature probably varied from about 0 degrees F. to 100 degrees F. The cellar varied only from 34 to 63 degrees during the year, and the changes were gradual.

The tests also indicate, although the differences are not great enough to prove conclusively, that seed which was dried in an atmosphere of 25 percent relative humidity, and then sealed (as all of the samples were), kept better than that which was either drier or moister. Such a degree of dryness is easily obtained in a room heated to 70 degrees, when the outside air is much cooler. In this case, the moisture content was about 4.5 percent of the seed weight, but it is not believed this is as good a criterion of the seed condition as the moistness of the air in which it was dried.

August 1929

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL, MINNESOTA

Breakage No Obstacle to Selective Logging

The loss of reserve trees in logging need not be a bugbear in selective cutting. Experimental cuttings at the northern hardwoods field station in the Upper Peninsula of Michigan show that the damage in selective logging to reserve trees by accidental breakage is not as serious as most people fear.

The losses in three selective cutting operations, covering 46 acres, amounted in "very light" improvement cutting to 0.5 percent and in both "light" and "heavy" cuttings to 2.1 percent of the total number of trees above $2\frac{1}{2}$ inches in diameter in the original stand. Most of the trees broken are usually small trees between 3 and 8 inches in diameter breast high.

On one 8-acre plot, for example, in a heavy selective cutting the trees broken were distributed by size as follows: 13 trees between 3 and 5 inches in diameter, 9 trees between 6 and 8 inches, 2 trees between 9 and 11 inches, 3 trees between 12 and 14 inches, and 1 tree in the 15-17 inch diameter class; or a total of 28 trees. This makes $3\frac{1}{2}$ broken trees per acre, mostly of small sizes.

On the basis of merchantable volume, the "loss" was almost negligible--21 board feet per acre. This is only 0.4 percent of the original volume, or 1.1 percent of the reserve volume. Even this loss was not a real loss, as the trees broken were cut up into logs and used.

On the other hand, in very heavy cuttings in which 92 percent of the total volume was removed--cutting approaching commercial clean cutting--the breakage was considerable, amounting to 26 percent of the total number of trees in the original stand.

Of course, in addition to trees so completely smashed that they had to be cut, many tops and branches were broken off and boles scarred up. This is not only injurious to the form and vigor of the tree, but may open the way for decay to enter. It has not yet been determined just how serious this type of damage may prove to be.

A further unnecessary loss of small trees often results from excessive swamping for skid trails and roads, and unregulated cutting of material for corduroy, car stakes, etc.

In the cuttings made on the experimental forest, no special precautions were taken to safeguard the remaining trees from breakage. With greater care the amount of damage due to breakage may be still further reduced. It all depends upon the care and skill used in felling the trees, which is largely a reflection of the attitude of the loggers. It is essential that the entire logging crew, from woods boss to swampers, be "sold" on the selective cutting idea--that they have a rough appreciation of the value of the 6-inch tree.

No. 16 August, 1929.

LAKE STATES FOREST EXPERIMENT STATION
University Farm, St. Paul, Minnesota

How Much Light Do Forest Trees Need?

Forest canopies intercept from 50 to 99 percent of daylight. Since plants require light for their growth, it is essential to know whether the amount of light which penetrates the leafy canopies is sufficient for the rapid and healthy growth of the young trees that come up under the shade of the older trees.

Dr. H. L. Shirley, formerly with the Boyce-Thompson Institute and now physiologist of the Lake States Forest Experiment Station, attempted to find an answer to this question. He grew in the greenhouse of the Institute young trees and plants under a series of cloth covers of different mesh, which gave shades corresponding to those in a forest.

The experiment showed that the trees tested survive if they get only 1 percent of normal daylight. Plants are unable, however, to make appreciable growth or to produce flowers and fruit when they get less than 8 percent of the daylight. Plants receiving from 10 to 15 percent of the daylight grew well, but were taller and weaker than those receiving from 30 to 50 percent intensity. The plants which received 50 percent of ordinary daylight usually produced as much growth or more than those growing in full daylight.

While forest canopies are seldom so dense that the young trees growing under them succumb from want of light, their growth under dense shade is usually too poor to be of much consequence. On the other hand, under very thin canopies which cut off about 50 percent of the full daylight, the shade may prove even more advantageous than full daylight.

The results of this investigation are embodied in a paper entitled, "The Influence of Light Intensity and Light Quality upon the Growth of Plants" which appeared in the American Journal of Botany 16:354-390. May 1929.

September, 1929.

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 18

Ordinary White Daylight is Best for Growth of Trees

The ordinary white daylight, as human eyes see it, is really a composite of light rays of different colors, ranging from deep red, through orange, yellow, green, and blue to deepest violet. As light filters through the leafy canopy, some of these rays are absorbed more strongly than others, hence the light which reaches the young trees on the ground is changed in color to some extent.

How essential are these different colors of light for the best growth of plants? Do they grow better in ordinary daylight, or would they grow better in red, blue, or yellow light?

The Boyce-Thompson Institute at Yonkers, New York, has for the last three or four years studied the effects of rays of different colors upon plant growth. Dr. H. L. Shirley, formerly with that Institute and now physiologist at the Lake States Forest Experiment Station, sums up the results of these experiments as follows:

Plants are grown in houses covered with different colored glass roofs. One glass transmits the light unchanged. Another removes the ultra-violet rays. A third removes all the red. A fourth transmits red, yellow, and green; and a fifth transmits mostly all red and yellow.

The plants live in all houses and grow to maturity. Those, however, which are grown in the red light are weak and spindly compared to the others, Those in the blue light look somewhat stunted, but weigh as much as any.

From these results it is concluded that white daylight is the most efficient for the growth of plants. While removing the ultra-violet and part of the blue seems to cause no bad effects, removal of all the blue is decidedly harmful. Removing all the red was much less less harmful than removing all the blue.

While the manufacture of carbohydrates in plants proceeds more efficiently in red light than in blue or green, apparently blue light plays some role in the growth of plants which makes it essential for their healthy development. The best development of plants takes place in the ordinary white daylight in which all colors are present.

September 1929

LAKE STATES FOREST EXPERIMENT STATION
University Farm, St. Paul, Minnesota

Technical Note No. 19

Why Nurserymen Prefer Southern Seeds

Nurserymen believe that seed of southern origin, produces larger plants more quickly grown to useful size, than does northern seed of the same species. This belief is substantiated by the first-year results of a study of various seed-sources for Norway pine. Localities for seed-collecting are compared on the basis of their summer temperatures, rather than by their latitude. So far, the evidence is that temperatures form the best single criterion for judging the growing conditions under which seed is produced, and for deciding whether seed is suitable for a given planting site.

In this study 41 lots of seed of the 1927 and 1928 seed crops were sown in the Cass Lake Nursery of the U. S. Forest Service in the spring of 1929. This nursery has a summer temperature of 63° F. Grouping the seed-lots into six geographical and temperature groups in order that individual variations may be eliminated, the results during the first season were briefly as follows:

Source		Number lots sown	Average germination		Average weight of**	
Locality	Summer temperature		Indoor test	In Nursery	1-year seedlings*	Seeds of same lots
	Degrees F.		Percent		Milligrams	
Upper Michigan	60	4	54.0	42.8	40.5	7.4
N.E. Minnesota	60 - 61	8	55.1	45.5	42.2	8.2
N.W. Wisconsin	60 - 62	9	48.1	48.3	45.6	8.3
Lower Michigan	62 - 63	9	54.3	46.1	48.8	8.5
Central Wisconsin and Minnesota	63 - 66	9	45.3	55.0	52.8	9.4
New England	64 - 65	2	75.0	66.0	55.5	9.4

These results, though limited in their scope, show with remarkable consistency that the seed of northern origin is smaller, that it produces smaller seedlings, and that its nursery "showing" in the matter of germination is not as good as that of seed from the southern portions of the range. The New England seed produced especially large seedlings but too much dependence should not be placed on only two samples. It is probably true that the southern portion of the range of Norway pine, even though it receives more rainfall than the northern portion, is less favorable for growth because of greater extremes of temperature, higher evaporation, and greater liability to drought. Hence, it is conceivable that larger seeds and seedlings are required in the south in order that the species may naturally establish itself. The slightly longer growing season may, however, aid in developing larger seeds.

While, then, it is obvious that seed from the warmer portions of the natural range of a species may possess some advantages in the ease with which they may be grown, the present experiment is expected to show that in the long run, after being planted-out under natural conditions, only seed from the same portion of the range develop into trees which are fully adapted to a given region or planting-site. It is possible that we may shortly have some experimental evidence on the frost-hardiness of the seedlings of different origin, which will be convincing in this respect.

* Tops only.

** Several lots had no excess of seedlings at end of summer and could not be sampled for weight. These two columns based on only 29 logs of seedlings and the corresponding seed lots.

September 1929

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

How Much Does It Cost to Thin?

Thinning dense forest stands is a thoroughly accepted practice for improving the ultimate yield and quality of the timber.

In Europe where the product of thinning even in very young stands has a commercial value, thinnings either pay for themsevles or even bring a profit. In this country, thinning, much as it may be desired from the standpoint of the good of the forest, is still a doubtful operation economically, because of lack of market for the product of thinning.

The Station, in connection with some other experiments, attempted to determine the cost of thinning in stands of different sizes and density. Three sets of conditions were encountered.

1. Eight acres were thinned in a dense jack pine stand 20 years old. The trees averaged about 2½ inches in diameter. The number of trees before thinning ran from 2,500 to 3,800 per acre. From 1,200 to 3,200 trees per acre were taken out or from 50 to 85 percent of the original number. The cost of thinning varied with the number of trees removed and amounted to from 10½ to 35 man-hours per acre. At a current wage of 37½ cents per hour, that meant an expenditure of $4 to $13 per acre. The product of thinning could not be sold. It even required additional expenditure for piling and burning the brush.

2. Seven acres were thinned in an aspen stand, also 20 years old. There were, on an average, 2,400 trees to the acre, 3 inches in diameter before thinning. The number of trees removed varied from 2,000 to 2,300, leaving from 100 to 400 trees to the acre. The labor involved ranged from 15 to 23 man-hours or at the current wage from $5.50 to $8.50 per acre. The trees cut were sold for cordwood and partially paid for the cost of thinning.

3. Three acres were thinned in a 53-year old pole stand of mixed jack and Norway pine. The number of trees per acre before thinning was 658, the average diameter 6.7 inches. The number of trees removed in thinning was from 158 to 200. The product obtained entirely paid for the cost of thinning and, if the plots had not been so far removed from a market, the thinning would have probably shown a profit.

These cost figures are too limited to permit drawing any general conclusions. The cost of thinning will vary with the cost and efficiency of woods labor, the size of the operation, and, above all, with the proximity to markets capable of using small stuff. Yet, it would seem that thinning may be justifiable in very young stands of, say from 5 to 10 years old, when the thinning can be done with a long knife (machete) at a cost not to exceed $1.00 or $1.50 per acre. Thinning is also justifiable, of course, where the product pays at least the cost. In aspen, that would mean at the age of about 25 years, in a mixed stand of jack pine and Norway, at the age of about 40 or 45 years. Thinning in intermediate stages, under the present economic conditions of north central Minnesota, is apparently not yet justifiable economically, except in rare cases.

No. 20 October 1929

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 21

How Long Does Hardwood Slash Remain a Fire Menace?

Inflammable material left after logging consists of small branches, large limbs, tops, logs, and stumps. Observations made over a wide territory in northeastern Wisconsin, and the Upper Peninsula of Michigan, during the last four years throws some light on how long this debris remains a fire menace and how the rate of decay varies with the kind of wood.

Small slash up to 2 inches in diameter of most northern hardwood species such as yellow birch, hard maple, basswood, elm, and beech is almost completely gone in 4 to 7 years. Small slash of white pine and hemlock which occur among the hardwoods remains a source of fire danger from 12 to 15 years.

Large tops, defective logs, and stumps left by the cutting operation constitutes a real source of fire danger in dry weather for a much longer time. Stumps usually decay before the logs do.

Basswood logs and stumps are no longer a serious source of fire danger after 10 to 12 years; after 15 to 18 years nothing remains except a rounded heap of mouldy wood.

Sugar maple and yellow birch in 15 to 17 years are so rotten that little inflammable fuel is left in them. The wood of yellow birch possibly rots a little faster than that of sugar maple, but yellow birch bark outlasts that of the latter. The two species, therefore, may be considered as having the same significance from the standpoint of slash danger.

Elm resists decay more than any of the northern hardwoods. Some stumps and logs of elm were found to be fairly solid as long as 25 to 30 years after logging. Although it is probable that 35 to 40 years are necessary to bring about complete rotting of elm stumps and logs, they apparently cease to be a serious fire menace in 20 to 25 years.

White pine, hemlock, and white cedar are more resistant to rot than hardwoods, with the exception of elm, and, therefore, remains dangerous for a longer time as fuel for forest fires. Stumps and logs of white pine were found in almost perfect state of preservation 35 to 40 years after first logging. White cedar and hemlock must be reckoned with as dangerous slashings for about 20 to 30 years.

These observations are based on average conditions. In wet or dry situations the rate of decomposition may be delayed beyond this average as much as ten years.

January 1930

LAKE STATES FOREST EXPERIMENT STATION
University Farm, St. Paul, Minnesota

Frost Hardiness of Races of Norway Pine Seedlings

The Lake States Station has previously expressed the opinion that there is no more certain cause of failure of forest plantings than seed of improper origin. Recently there has been called to our attention a case of extensive winterkilling of Norway pine in northern Wisconsin, apparently due to the use of seed imported into this region from Pennsylvania and other points in the East. Such failure is not surprising when one considers that, even when a point in the Northeast with summer temperatures similar to ours is selected, the Norway pine can not be adapted to our very low winter temperatures -- the differences being generally from 10 degrees to 15 degrees between the two regions.

In Technical Note No. 10, we mentioned possible experimental data on the frost hardiness of seedlings, to bear out our contention that the larger seed and seedlings from the warmer portions of the range of Norway pine were not suitable for use in the colder parts of the range. Such data have been obtained after repeated trials to find the temperature which would affect the least hardy seedlings, but would not kill all. The seedlings were grown in pots from April to December, under artificial conditions. Two hundred pots of seedlings were started for these tests, but owing to early death of seedlings in many, and the use of many others for preliminary trials at other temperatures, only 41 were available for the final and decisive test. Seeds of 28 different collections were represented. At 10.4 degrees and 17.6 degrees F, all seedlings of all sources had been killed. The killing temperature, 20 degrees F, applied after 7-10 days "hardening" at 32 degrees F, can not be expected to apply to seedlings grown under other conditions, or of a different age.

If we divide the entire region from which the 28 seed collections were derived, along the line which denotes a mean summer temperature of 62 degrees F, we find that there is a very significant difference in the hardiness of the seedlings from north and south of that line, the more northern forms surviving to the extent of 51 per cent while those from the warmer half of the range of Norway pine survived only to the extent of 10 per cent. In the territory north of the line, the narrow strip of Wisconsin near Lake Superior, and the Upper Peninsula of Michigan made a better showing than the area of northeastern Minnesota, but it is doubtful whether this difference means much. Likewise, of the warmer regions, the southern portion of the Norway range in Minnesota and Wisconsin made a much better showing than the upper half of the Lower Peninsula of Michigan. The latter area, and the area represented by a single seed sample from New Hampshire, have much milder winter conditions than the corresponding zones of Wisconsin and Minnesota, and this "softness" of the Michigan representatives may be explainable on this basis.

The most important point to be borne in mind is that a zone or region which habitually produces the more hardy forms of a species requires such forms for safety and success in reforestation. It is, therefore, to be hoped that nursery and field data to be secured later, on stock now being grown, will help outline the different regions with greater certainty.

A more detailed account of this test has been prepared for publication in the Journal of Forestry.

January 1930.

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA
No. 23

One Year of Storage Benefits White Pine Seed

Everyone who has attempted to grow white pine nursery stock is familiar with the fact that the germination of the seed is very "unreliable." Seed of this species loses its vitality sooner than most other pines, and even fresh seed cannot be depended upon to give prompt germination and even stands, unless sown in the fall, which is not always feasible. Otherwise much of the seed may germinate near the end of the summer, or even in the second year, producing ragged and unsatisfactory stands and great variations in size of trees.

Not only has the Lake States Forest Experiment Station been seeking the causes of the slow and uneven germination of white pine, but it has under way storage tests through which the germination of the seed at various ages may be studied, and the best method of preserving its vitality, as well as the best time to use it may be determined. Thus, fresh seed collected in the fall of 1928 and extracted with the utmost care could not immediately be made to germinate more than 40 percent by any treatment applied to it, and this germination was slow and straggling. Even samples of this seed which were held over winter in moist sand, at cellar temperatures, did not exceed 50 percent germination until they had been in the ground 90 days, after which they took a new "spurt" and climbed to about 60 percent. Seed which has been similarly stratified and frozen hard was inferior to that which was merely kept cool.

In contrast to the above unsatisfactory behaviors, samples of this same seed which have been stored for one year (until December 9, 1929) then soaked over night in 0.2 percent sulphuric acid, and sown immediately, have germinated nearly 56 percent in the first 44 days after sowing, with indications that this is nearly the full capacity of the seed. Even more remarkable than this relatively quick and satisfactory germination is the uniformity of the sixteen samples thus treated, which except for slight effects of different storage conditions, have behaved very nearly the same. As between storage at an even temperature of 32° F, in a cellar with a yearly range from about 30° to 60° F, and in a shed with a temperature range from about 20° to 100°, it would probably be misleading to attempt to draw any certain distinctions at this time, although the cool cellar has somewhat "the best of it." These three types of storage were all in sealed bottles. Seed stored in the shed without air-tight sealing is about 10 percent inferior to the others, possibly not enough to cause great concern if storage is limited to one year. A slight preliminary drying of the seed, from 9 percent to about 7 percent moisture, appears to have given better results than the seed stored with either more or less moisture. However, if the cones had been opened by artificial heat, any additional drying of the seed would probably have been unnecessary.

It is learned that many nurserymen, when compelled to sow white pine seed in the spring, stratify it for a few weeks in moist sand, sawdust, or other moisture-holding medium. Since soaking for short periods has not given greatly increased germination, these methods will be next investigated, particularly with reference to the length of time required for the greatest effect, the degree of wetness that should exist in the medium, and the temperature at which the seed may best be held to prevent premature germination.

MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

January 1930

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE . . . FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Germination Tests for Coniferous Seeds

Since the preparation of Technical Note No. 12, in March 1929, the Lake States Forest Experiment Station has greatly increased its equipment and facilities for the testing of forest tree seeds, so that uniform temperatures and moisture can be maintained while retaining the undeniable advantages of tests made in sand. In addition, much knowledge has been gained as to the germination behavior of seed, particularly as to the most favorable temperatures for this process. While with Norway and white pines an even temperature of about 70 degrees F now appears to be very near the optimum that can be provided, undoubtedly more exhaustive studies will show that certain variations from this temperature are desirable in some cases. It will, however, be the intent to adhere to a standard and unvarying practice with each species, so far as possible, this being especially important where it is desired to test samples from the same lot of seed year after year, or at more frequent intervals.

Cooling as well as heating apparatus have been installed at University Farm, so that the same temperature conditions for germination can be had at any season of the year. However, as most seed is wanted for spring or fall sowing, it is hoped to avoid any extensive testing in the middle of the summer, and those who have samples to send in are urged to do so well in advance of the time when the information on the seed will be wanted. The following minimum periods for germination tests may be allowed, although some indications of seed values may be had, and incomplete reports will be made, if so requested, after shorter periods:

Norway pine	- 40 days	White pine	- 60 days
Jack pine	- 26 days		
White and black spruces	- 30-90 days (very variable)		

The Lake States Station has as yet made no special studies of the germination of hardwood seeds, but will attempt gradually to work into this field if there is any demand for such service.

Seed samples of all of the conifers, sent to the Lake States Station for testing, should ordinarily consist of about one-fourth pound of material, (including the normal amount of foreign matter) selected with the greatest care from the larger stock which such a sample may represent. If the sample is not taken with care by the sender, so as to be truly representative, then all of our effort to maintain a high degree of accuracy will be wasted. While the above amount may contain several times as many seeds as we shall actually test, it permits us to take one to three samples of the exact size which we need, and the unused residue will always be returned to the sender if it is desired.

With the seed, which should be packed or wrapped in such a way as to prevent crushing in the mails, the sender should enclose as much information as possible, and particularly absolute identification of each sample. For our intelligent treatment of the samples, and for the gathering of general information, we shall in most cases ask senders to fill out a record card, one copy of which will be returned with the germination record in full. Those who expect to use this service regularly may well supply themselves with cards in advance.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Ground Vegetation--An Indicator of Forest Growth

Certain herbaceous and woody plants in the forest are as characteristic of certain forest types as are the trees themselves.

In its numerous studies, the Station has found that wherever there is a jack pine forest the ground cover under it is made up of bearberry, blueberry, sweet fern, and reindeer moss. In the hardwood forests of maple-birch-basswood the ground hemlock, beech, and maiden-hair ferns are the most characteristic plants. In swamp forests leatherleaf, labrador tea, sphagnum, and creeping snowberry are the most common associates.

Certain plants are characteristic not only of a given forest type but also of its growing capacity. In aspen, for instance, sweet fern indicates poor growth of only about two-tenths of a cord per acre per year, and the stands seldom reach merchantability. A ground cover of clintonia, meadow rue, and wild ginger, on the other hand, indicate a growth of close to nine-tenths of a cord per acre per year.

In jack pine, abundant hazel brush indicates a possible growth of nearly nine-tenths of a cord per acre per year. Blueberry and sweet fern indicate a growth of about two-thirds of a cord per acre per year. Where the ground cover is grey or green lichens, commonly known as reindeer moss, the growth may be expected to fall below one-half cord per acre per year.

In pure white pine, ground vegetation of twin flower, bracken fern, trailing arbutus and wintergreen indicates a mean annual growth of only about 90 board feet per acre per year at 50 years. Shield fern, solomon seal, hepatica, and yellow wood sorrel indicate a growth of about 215 board feet per acre. When mandrake, jack-in-the-pulpit, maiden-hair fern, and downy yellow violet are present, the growth may be as high as 315 board feet.

Wet spruce and tamarack swamps are commonly covered with leatherleaf, labrador tea, sphagnum, sedges, and polytrichum mosses and the growth does not exceed one-sixth of a cord per acre per year. Hardwood swamps on the other hand, may have a growth close to a cord per acre per year, and have a characteristic ground cover of currants, elderberry, violets, service berry and maianthemum.

Thus each kind of forest has its characteristic plants and certain plants indicate the growing capacity of the forest.

September, 1930.

*Maintained by the U.S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 26

More Light in the Forest?

To think that there may be more light under the shade of the forest trees than in the open seems absurd, yet this may happen in some forest stands. Recent measurements of light intensity carried on by the Station, on the Chippewa National Forest, showed that on some spots in a thinned aspen plot the light intensity was actually higher than in the open. Values of 100 to 107 percent of total light were recorded several times. When the light measuring device was shaded from direct sunlight both in the open and the forest, the percentages were still higher -- sometimes 120 to 140 percent of skylight.

These higher light intensities in the forest occur only in spots where the sun's rays penetrate the canopy unobstructed by leaves, and where the direct rays are augmented by light reflected from leaves. Aspen, birch and other light colored or shiny leaves reflect a large proportion of the light they receive, while reflection from pine and other darker colored leaves is much less. In no case were intensities of over 100 percent found in pine stands unless a birch or other hardwood was present to reflect the light. The effect is quite similar to that produced on the sunny side of a white building as compared to the sunny side of a dark colored building. The reflection of light from the white surface makes a brighter spot than occurs any place in the open.

Records of greater light intensity in the forest than in the open are of course exceptional. Average intensities under 5 aspen stands of different densities were 41, 37, 34, 23, and 12 percent of total light in the open.

These light relations have a direct bearing upon the success of underplanting aspen stands with pine and spruce. The investigations indicate that pine and spruce seedlings are not likely to die from lack of sufficient light when they come up under the shade of aspen stands, providing there is no understory of hazel or fern. Such understories may reduce the light intensities below 5 percent, a value too low for good survival in this region. For best growth an intensity of thirty percent is required.

The competition not only for light, but also for moisture and soil nutrients, which the shrubby and herbaceous understory offers to pine and spruce is often more important in determining the early survival and growth of conifers planted under aspen and other hardwoods than the upper canopy itself.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

By the Forests Ye Shall Know the Birds

There is a close conformity between the type of forest cover and the animal life that inhabits it.

An investigation during the past summer by the forest biologist attached to the Station showed that certain groups of birds are as characteristic of certain types of forest cover as the trees in the forest themselves. For instance the purple finch, the siskin, the crossbills, and the kinglets are seldom to be found away from evergreens. The pine warbler is a sure indicator of the presence of Norway pine in its vicinity. The spruce partridge points to a balsam-spruce forest as its home.

Heavy aspen-white birch forest always has its complement of breeding oven birds, Least flycatchers, and veeries, and the tamarack swamp is sure to hear the courtship song of the olive-backed thrush.

Each forest type seems to have its accompanying fauna - red squirrels in the evergreens, porcupines near white and Norway pines, and certain species of toads, frogs, snakes, and turtles for each group of tree associations.

That the forest cover is essential to the well-being of our wild life has long been appreciated by everyone who has given conservation matters any thought. But that the forests are greatly influenced by the wild life they shelter is a point that few people realize. We are only beginning to comprehend the immense value of certain birds and animals to our forests through their insectivorous habits. They control many pests that in their absence might wipe out acres of timber. We have just begun to understand such vital truths that the abundance of snowshoe rabbits today has a great bearing on the timber crop of 50 years hence.

So the Station, in cooperation with the United States Biological Survey, is launching studies of birds, mammals, reptiles, and amphibians to determine the exact relationships of the various vertebrates to the forest.

September 1930.

*Maintained by the U.S.Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

Technical Notes

No. 28.

LAKE STATES FOREST EXPERIMENT STATION[1]
University Farm, St. Paul, Minnesota

Germination and Survival of Conifers under Aspen

As a part of its investigation of the possibility of converting aspen into coniferous forests, the Station established three plots in aspen on the Chippewa National Forest last fall. One plot was clear cut, thirty-five percent of the stand was removed from the second, and the third was left uncut.

This spring Norway pine, white pine, and white spruce were sown in 50 specially prepared spots on each plot. Thirty-two days after sowing the clear-cut plot had Norway pine seedlings in 48 spots, white pine in 26, and white spruce in 21. The partially cut plot had Norway pine in 14 spots, white pine in 4, and spruce in 5. The uncut plot had Norway pine in 14 spots, white pine in 2, and spruce in 8. Since the seed was sown with equal care in all three plots, the difference in germination is probably due to the higher soil temperature of the clear-cut plot.

Last fall 425 Norway pine and 425 white spruce were planted on each of the three plots. During the winter and early spring 51 spruce died on the clear-cut plot, 31 on the partially-cut plot, and 28 on the uncut plot. Some spruce have died since May on the clear-cut area. Norway pine showed practically 100 percent survival in all three plots. From the standpoint of germination and survival, there seems to be little difference between the clear-cut and uncut stands.

While clear-cut plots apparently offer the most favorable place for the early germination of seed, they fail to afford the protection from the rigors of winter and early spring for planted stock that uncut and partially cut stands do.

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1/Maintained by the U. S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Pre-treatment of White Pine Seed

for Spring Sowing

Stratifying the seed in a moist medium and putting it away in a cold cellar for 30 days prior to sowing overcomes the sluggishness of white pine seed sown in the spring. Tests made with stratified seed have conclusively shown that stratification increases the germination per cent in the laboratory from 20 to 95 at the end of 45 days and that the pretreated seed completes 90 per cent of its total possible germination within 20 days after sowing.

The suggestive experiments in seed stratification by the Boyce Thompson Institute were entirely confirmed and put upon a practical basis by the Station's tests. Five different germinating media (Sphagnum moss, hardwood sawdust, pine sawdust, acid sand, and limed sand), two degrees of moisture in each media, three storage temperatures (33, 50 and 60 degrees F), and three periods of storage (15, 30 and 60 days) were tested. The results represented in the table below:

Total Germination at End of 40-47 Days

Stratification period days	Untreated checks	Av. all media storage at 33 Degrees	50 Degrees	60 Degrees	Average of 4 samples for each media 1): Sphagnum Av. excluding 60 degree treatment	Sawdust: Hardwood	Sawdust: Pine	Sand with: Acid	Sand with: Lime
	%	%	%	%	%	%	%	%	%
15	18.0	64.6	7[illegible].1	44.5	72.5	75.7	73.6	53.2	62.8
30	24.4	88.9	89.8	36.3	86.6	92.4	93.1	83.8	91.1
60	22.4	91.7	90.0	-	87.0	93.2	92.4	91.4	92.5

1)Including 33 degrees and 50 degrees storage for each, 100 and 200 per cent moisture for sawdust, 400 and 700 per cent for sphagnum, and 3 and 5 per cent for sand. The latter would have been more effective had the moisture been thoroughly mixed into the sand instead of being applied to the top.

As a result of these tests it can be definitely recommended that when it is desirable to sow white pine seed in the spring, it be mixed with sand or sawdust previously moistened, and be put away in a cellar whose temperature is between 33 and 50 degrees F., for a month before the normal date of sowing. The sand or sawdust should be sifted while dry, through openings of not more than 7/64 inch, which sized mesh will pass very few seeds. This fine material should then be wetted with 1-2 times its own dry weight and the seeds thoroughly mixed into it. After standing 30 days, with occasional shaking or stirring, the media may be partially dried so that it can be worked through the same screen without difficulty. The seed should then be sown promptly. From the standpoint of ease of separation, fine pine sawdust can be recommended above any other media for holding the moisture.

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*Maintained by U.S.Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION[1/]
University Farm, St. Paul, Minnesota

Centers for Collecting Seed of Norway Pine

As a result of the seed-collecting activities of this Station, it is now possible to outline eight regions or areas in the Lake States which form fairly distinct centers for the collection of Norway pine seed, as based on the occurrence of sufficient stands, and which are yet reasonably distinct climatically, or at least have a climatic and a forest type basis for their differentiation. These areas are shown on the map on the reverse side. It is hoped that this information may lead to somewhat better utilization of seed sources not now fully employed and at the same time permit users outside the region to practice some selection. It seems evident, for example, that areas 2 and 7 might well be employed by planting agencies of the Northeast, while the requirements of area 8 should be filled locally more than they are at present.

1. Cass Lake-Itasca Park Area. This is characterized by extensive stands on light glacial soils or outwash sands. Extends somewhat west of Bemidji and north to Red Lakes, south to northern Wadena County, with eastern boundary possibly as far as Grand Rapids. Outstanding for virgin timber remaining , whose qualities may justify the favor in which seed from this region is held. While the summer temperatures of this region are not as low as the latitude might suggest, it should be realized that the winter temperature is extremely low and this may lead to slower growth than would be obtained from more southerly or easterly stock.
2. Brainerd-Cameron Area. Mainly second-growth on the sandy plains, in a narrow belt from northeastern Todd County to Pine County, (embracing Mille Lac), and southeastward to Cameron, Wisconsin. In general represents the southern extension of Norway in Minnesota.
3. The Ely Area. Embraces the central portion of St. Louis and Lake Counties back from Lake Superior, but may be said to extend north into western Ontario. Undesirable except for local use since climatic soil conditions tend to produce seed of low vigor.
4. Bayfield Area. This embraces the territory in Carlton County, Minnesota and eastward to northern Iron County, Wisconsin, where climatic conditions are dominated by Lake Superior. Generally sandy lake and outwash soils. Produces vigorous seed and probably a hardy type. Virgin remnants near Barnes and Winnebijou.
5. The Upper Peninsula Area, excluding the areas adjacent to northeastern Wisconsin. This is similar to 4, extending across the northern portion of Upper Michigan, mainly on Lake sands. Produces generally good seed and probably the hardiest stock.
6. Woodruff Area. This large area, north of a line from St. Croix Falls to Manitowoc, Wisconsin and into Upper Michigan, south of areas 4 and 5 is generally in the northern hardwood type. A sandy area encouraging much Norway pine centers around Woodruff, extending as far south as Tomahawk and more scatteringly down the Wisconsin. Throughout most of regions, there is some Norway pine on light soils.
7. The Eau-Claire-Kilbourn Area. This includes the outliers of Norway pine, mainly found on sandstone butts along the southern border of the range associated with the oak-hickory type. Probably a sturdy and desirable stock for planting under fairly mild conditions. (Summer temperatures 64° or more.)
8. The Lower Michigan Area. This includes Lower Michigan from Bay City north, the greatest concentration of Norway pine being on the sand plains and hills of the eastern and central portions.

February 1931

1/ Maintained by the U. S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota

NORWAY PINE SEED COLLECTING REGIONS IN THE LAKE STATES

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL, MINNESOTA

Selective Logging and Close Utilization - A Solution to the Slash Problem in Northern Hardwoods

Measurements on representative cutover areas in northern Wisconsin and on the Upper Peninsula Experimental Forest at Dukes, Michigan, show the following relationships between degree of cutting, degree of utilization, and the amount of slash.

Kind of Cutting	Sawlog Volume Cut Per Acre	Percent of Original Sawlog Volume Cut	Percentage of Ground Covered by Slash: Heavy 1/ 1'-10'	Medium 4"-1'	Light 1"-4"	Total	"Slash Space" (Depth x Area) Per Acre
	Bd. Ft.	Percent	Percent				Cu. Ft.
Hemlock-Maple-Birch Forest - Wisconsin							
Selective	9,040 2/	77	8	13		21	11,540
Clear cut	8,594	97	34	7		41	60,740
Maple-Birch Forest - Dukes, Michigan							
Selective	3,505	39	1	4	3	8	2,250
Selective	4,523	44	2	5	20	27	4,640
Selective	6,773	68	2	10	18	30	5,950
Clear cut	10,372	100	4	12	8	24	11,040
Clear cut	11,934	100	4	20	8	32	13,360

1/ Figures show depth of slash corresponding to different grades.
2/ Cut was mostly of very large trees.

"Slash space", expressed in cubic feet, which is the depth of slash multiplied by the area occupied by it, is used as a basis for comparison. On the clear-cut hemlock-hardwood plots, there is over four times as much slash as on the clear-cut plot in pure hardwoods. Hemlock cuttings leave more heavy slash than hardwood cuttings of the same volume. The Wisconsin plots, besides having over 50 percent hemlock, were cut for sawlog material only. On the Michigan plots, utilization was much closer, for, in addition to sawlogs, from 13 to 38 cords of "chemical wood" were cut per acre from the tops, cull pieces, and small trees.

Selective logging and close utilization contribute materially to the solution of the slash problem in the Lake States.

 February, 1931

MAINTAINED BY THE UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 32

Drought Resistance of Forest Plants

During the prolonged dry period of the summer of 1930, many plants growing in the forest suffered severe injury and death. This presented an opportunity for a study of the relative ability of the different plants to withstand drought. Four one-acre jack pine plots on the Chippewa National Forest were chosen for the study. Each species of plant growing on each plot was listed as thrifty, poor or dead.

The plants on these four plots are listed below according to their condition on August 22, 1930.

Plants resistant to drought	Plants injured by drought	Plants killed by drought
Inland Jersey tea	White spruce	Blueberry
Asters	Red oak	Wintergreen
Goldenrod	Burr oak	Trailing arbutus
Large toothed aspen	Jack pine	Sedge
Norway pine	Willows	Wild pea
Bearberry	White pine	Bracken fern
	Hazelnut	Everlasting
	Fire cherry	Tamarack
	Choke cherry	
	Paper birch	

While the results of this study apply mainly to the sandy soils commonly occupied by jack pine, certain features are of interest. Blueberry is often found growing on dry places, yet it is relatively susceptible to drought. Norway pine seems most resistant of all conifers, but jack pine, which is somewhat less drought resistant, grows on the drier soils. Jack pine is relatively shallow rooted, which probably accounts for its poor showing. It appears, therefore, that the actual growth requirements of a plant can not be accurately predicted from a study of the places it commonly grows. People who plant forest trees on dry situations will probably secure best results from Norway pine.

February 1931

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

LAKE STATES FOREST EXPERIMENT STATION 1/
University Farm, St. Paul, Minnesota

Effect of Forest Cover On Drought Injury to Undergrowth

In 1926 four one-acre sample plots were established in 55-year-old jack pine on the Chippewa National Forest. Three of the plots were cut in varying degrees while the fourth was left uncut. The original purpose was to discover which method of cutting might favor Norway pine reproduction.

On August 22, 1930, at the height of the dry period, observations were made on the thrift of the plants found growing on these plots. Each plant was listed as thrifty, poor, or dead. The summarized results are shown in the table below:

Type of cutting	Number of trees left	Percent of normal basal area left	Total number of plants observed	Condition of plants: Thrifty	Condition of plants: Poor	Condition of plants: Dead
				Percent		
Heavy cutting............	108	15	45	15	38	47
Moderate cutting..........	205	45	47	21	45	34
Light cutting............	239	58	47	23	43	34
No cutting...............	355	93	50	46	48	6

The more dense the forest canopy, the better is the survival of the plants underneath. Protection from direct sunlight seemed to be necessary for good survival during drought. This fact was confirmed by observations elsewhere on the forest.

These findings have a direct bearing on planting practice. Where injury from drought is likely to occur, trees should be planted where they will receive shade during the hottest part of the day. The north sides of stumps, snags, logs and other objects should prove to be favorable spots. Natural vegetation, such as willows, alder or large toothed aspen, will provide a good protective shade. Dense hazel brush and aspen suckers should be avoided, however, as they cast shade too dense for normal growth of young trees.

February 1931

1/ Maintained by the U. S. Department of Agriculture at St. Paul, Minnesota in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 34

Fire Hinders Conversion of Aspen to Pine and Spruce

Aspen or popple occupies about two-thirds of the present forest area of Wisconsin and Minnesota. How these lands may be converted to the much more valuable pines and spruce forms one of the major projects of the Station.

To test whether a fire in aspen offers a favorable planting site for conifers, 10-foot square plots were burned with a torch in the fall of 1929. Four burned plots, alternating with unburned check plots, were laid out in clear-cut aspen, partially cut aspen, and uncut aspen. After burning, they were planted to pine and spruce.

When examined one year later, there was no significant difference in the survival of the conifers on the burned and unburned plots, but there was a decided difference in the number and heights of the aspen root suckers.

	Clear cut		35 percent of stand removed		Uncut	
	Burned	Unburned	Burned	Unburned	Burned	Unburned
Average number of aspen suckers per plot.............	133	100	14	9	8	9
Equivalent number per acre.........	58,000	43,500	6,300	3,800	3,300	3,800
Average height of suckers, feet....	3.53	3.22	2.25	1.67	2.43	1.97

The stimulation of aspen growth on the burned plots was probably due, not to a fertilizing effect of the ash or to the heat of the fire itself, but rather to increased soil temperature caused by the absorption of sunlight by the blackened surface.

Since aspen root suckers offer the most serious competition to young pines and spruce, any treatment which favors aspen is unfavorable for pine. Hence, neither on cut-over nor mature aspen areas can burning be recommended for improving planting conditions for conifers.

February 1931.

MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

LAKE STATES FOREST EXPERIMENT STATION 1/
University Farm, St. Paul, Minnesota

Sunlight and Forest Growth

All green plants require sunlight to carry on the process of photosynthesis, - the manufacture of sugars and starches from carbon dioxide and water. Plants in temperate regions which grow in open fields and meadows commonly get an abundance of sunlight, but in the forest competition for light is most keen. A plant must either get above its neighbors or submit to gradual starvation from lack of sufficient light.

Foresters are particularly anxious to get a new crop of trees started before the old crop is completely removed. A common method is to cut "selectively," removing only a part of the stand and in this way increase the light on the forest floor to a point where it is favorable for young tree growth. Just how much light is needed has long been a controversial question. To get information on this question, light measurements were made on fifty sample plots in a virgin Norway pine stand on the Chippewa National Forest. The age, density and height of the young trees growing on these plots were determined. The study shows that the density, height and thrift of the young growth very definitely increase with the amount of sunlight available. The average yearly height growth for trees 10 to 20 years of age and up to eight feet in height was negligible where the light was below 5 percent of normal sunlight; at 20 percent, it averaged about 0.1 foot per year; at 40 percent, 0.2; and at 80, about 0.35.

Of course, where sunlight is abundant, there is less competition from roots for soil moisture and nutrients. Hence light is not alone responsible for the increased growth observed in small openings, but it does serve as a fairly reliable index of the growth possibilities.

February 1931

1/ Maintained by the U. S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 36

Open-Grown Trees of the Same Height and Diameter Have Less Volume

In the open-grown trees, the taper is more rapid and consequently the volume is less than in trees grown in dense stands. The use of volume tables prepared for trees in dense stands gives, therefore, larger volumes than actually are found when applied to open stands. By actual measurements, this difference was found to be in favor of well-stocked stands by 6.5 percent for aspen, 5.6 percent for paper birch, 1.7 percent for jack pine, and 5.4 percent for black spruce.

The method of computation may also affect the volumes. One hundred and thirty-three trees from northern Wisconsin of aspen, paper birch, and jack pine, worked up by the Smalian formula (using 8-foot sections), gave volumes 3.3 percent, 6.2 percent, and 7.4 percent respectively larger than by the planimeter method. The planimeter method manifestly gives more accurate results.

To make the volume tables for aspen, jack pine, and paper birch, published in Technical Bulletins Nos. 39 and 60 of the Minnesota Agricultural Experiment Station, applicable to understocked stands, the values must be reduced by 9.8, 11.8, and 9.1 percent respectively because the volume tables published are based on trees from well-stocked stands and were worked up by the Smalian formula.

In the case of black spruce, in Minnesota Technical Bulletin No. 57, the volume tables were based on trees from a dense stand but were computed by the planimeter method. When applied to understocked stands, the values should be reduced by 5.4 percent of those published.

February 1931

Volume of Second-Growth Norway Pine
Board feet - International (1/8") Rule

Tree measurements obtained as a part of the study of volume and growth on the cut-over lands of Vilas, Oneida and Bayfield Counties, Wisconsin, form the basis for the following volume table. The measured trees occurred in pure and mixed stands as they were found along the survey strips. This is the first volume table for second-growth Norway pine in the Lake States in board feet, International Rule.

Wisconsin 1931

Diameter Breast High	Total height of tree - feet								Basis
	40	50	60	70	80	90	100	110	
Inches	Volume - board feet								Trees
7	13	24	33	41					18
8	19	34	46	57	67				23
9	26	44	60	75	89	100			18
10	33	55	76	95	113	131	149		27
11	41	67	94	118	140	161	185		22
12	49	82	114	145	170	198	225		14
13	58	97	136	172	205	238	270		10
14		116	162	204	241	280	319		11
15		137	190	240	282	326	370		12
16		159	220	276	324	375	425	480	9
17		180	250	314	365	424	480	540	10
18			282	352	410	472	539	606	7
19			315	397	460	529	600	672	3
20			350	435	510	584	660	740	7
21				480	560	638	720	810	5
22				530	610	700	784	880	2
Basis	19	52	17	25	30	31	22	2	198

Average deviation: ±7.8 percent Aggregate difference. -0.209

Stump height, 1 foot; top diameter inside of bark, 5 inches.
Block indicates the range of field data.
Trees were scaled in 16.3-foot log lengths and the table was constructed from these volumes by the alinement chart method.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Volume of Second-Growth Norway Pine
Board Feet - Scribner Dec. C

Tree measurements obtained as a part of the study of volume and growth on the cut-over lands of Vilas, Oneida and Bayfield Counties, Wisconsin, form the basis for this volume table. The measured trees occurred in pure and mixed stands as they were found along the survey strips. This is the first volume table for second-growth Norway pine in the Lake States in board feet, Scribner Dec. C rule.

Wisconsin 1931

Diameter Breast High Inches	Total height of tree -- feet										Basis
	30	40	50	60	70	80	90	100	110	120	Trees
	Volume - board feet										
7		1	1	2	2						18
8	1	2	2	3	4	5					23
9	1	2	3	5	6	7	8				18
10	2	3	5	6	8	9	10	12			27
11	2	4	6	8	9	11	13	15			22
12		5	7	9	12	14	16	18			14
13		6	8	11	14	16	19	21			10
14			10	13	16	19	22	25	28		11
15			12	15	19	22	26	29	33		12
16			13	17	21	26	30	33	37		9
17			15	19	24	29	33	38	42		10
18				22	27	32	37	42	47		7
19				25	30	36	42	47	52		3
20				27	34	40	46	52	58	64	7
21					37	44	50	57	63	69	5
22					40	48	55	62	69	75	2
23					44	52	60	68	75	82	
Basis	5	14	52	17	25	30	31	22	2		198

Average deviation: ± 8.6 per cent   Aggregate difference: -0.08 per cent

Stump height, 1 foot; top diameter inside bark, 6 inches.
block indicates the range of field data.
Trees were scaled in 16.3-foot log lengths and the table was constructed from these volumes by the alinement chart method.

February 1931.

*Maintained by the U.S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Technical Notes No. 39

LAKE STATES FOREST EXPERIMENT STATION[1]
University Farm, St. Paul, Minnesota

Volume of Second-Growth Norway Pine
Cubic Feet

Tree measurements obtained as a part of the study of volume and growth on the cut-over lands of Vilas, Oneida and Bayfield Counties, Wisconsin, form the basis for the following volume table. The measured trees occurred in pure and mixed stands as they were found along the survey strips. This is the first volume table for second-growth Norway pine in the Lake States expressed in cubic feet.

Wisconsin 1931

Diameter Breast High	Total height of tree - feet										Merch. volume	Basis
	20	30	40	50	60	70	80	90	100	110		
Inches	Volume - cubic feet										Percent	Trees
1	.054	.073										8
2	.232	.302										7
3	.510	.675	.86									5
4	,857	1.12	1.49	1.84							58.5	3
5	1.31	1.75	2.26	2.80	3.40						82.0	17
6	1.81	2.48	3.20	4.10	5.00						86.0	19
7		3.30	4.20	5.45	6.85	8.5					91.0	18
8		4.25	5.55	7.12	8.90	11.0					92.5	21
9		5.40	7.15	9.20	11.4	13.9	16.4				93.5	18
10		6.75	9.00	11.4	14.0	17.1	20.2	23.0			94.2	27
11			10.9	13.8	17.1	21.0	24.3	27.6			94.8	21
12			12.8	16.1	20.1	24.4	28.2	32.0			95.2	14
13			15.0	19.1	23.5	28.4	32.8	37.0	41.2	45.0	95.5	8
14			17.5	22.2	27.2	32.7	38.0	42.9	47.7	52.0	96.0	11
15			20.2	25.4	31.0	37.3	43.4	49.0	54.0	58.8	96.1	11
16				28.6	34.7	42.1	48.7	55.0	61.0	66.5	96.3	9
17				32.0	39.0	47.0	55.0	62.0	68.5	75.0	96.5	10
18				35.8	43.5	52.6	61.0	69.0	76.8	84.0	96.7	7
19				39.5	48.0	58.0	67.5	77.0	85.5	94.0	96.8	3
20					53.5	64.8	74.9	85.3	95.0	104.0	96.8	8
21					58.8	71.5	82.4	93.0	103.0	112.0	96.8	5
22					64.2	78.0	90.5	102.0	112.0	120.0	96.8	2
Basis	24	16	26	58	17	27	29	30	23	2		252

Average deviation: ± 6.32 percent   Aggregate difference: + 0.004 percent

Total volume includes stump, stem, and top without bark.
Merchantable volume, expressed in percent of total volume, includes the main stem above a one-foot stump to a top diameter of three inches inside bark.
Block indicates the range of field data.
The volume of each tree was obtained by the planimeter method. The table was constructed from these volumes by the alinement chart method.

MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

February 1931.

1/ Maintained by the U. S. Department of Agriculture at St. Paul, Minnesota

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 40

Volume of Black Spruce
Merchantable - Cords

Black spruce stands as they are found in swamps throughout the northern part of the Lake States are neither well stocked nor even aged. Trees in such stands give less volume than trees of the same height and diameter in dense even-aged stands. When compared to Table VI, University of Minnesota Technical Bulletin No. 57, sample trees used for the preparation of this table gave on the average 5.4 percent lower volumes. Tree measurements were obtained as a part of the study of volume and growth on the cut-over lands in the Lake States.

Minnesota-Wisconsin 1930

Diameter breast high	Total height of tree - feet: 20	30	40	50	60	Cordwood converting factors	Basis
Inches	Volume - cords					Cu.ft.	Trees
4	.009	.013	.017			78	44
5	.015	.022	.028	.035	.041	82	33
6		.032	.041	.051	.061	84	18
7			.056	.069	.082	86	3
8			.073	.089	.105	87	6
9			.091	.107	.127	88	3
10			.106	.130	.158	89	
Basis	27	56	17	5	2		107

Average deviation: ± 5.4 percent   Aggregate difference: -0.52 percent

Volume includes the stem with bark above a 1-foot stump to a 3-inch top diameter inside of bark. To exclude bark, multiply volume by 0.85.
Computed by dividing unpeeled merchantable volumes by the converting factors taken from Minnesota Technical Bulletin No. 57.
Block indicates the range of field data.

February 1931

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Volume of Black Spruce
Cubic Feet

Black spruce stands as they are found in swamps throughout the northern part of the Lake States are neither well-stocked nor even-aged. Trees in such stands give less volume than trees of the same height and diameter in dense even-aged stands. When compared to Table III, University of Minnesota Technical Bulletin No. 57, based on a dense even-aged stand, sample trees used for the preparation of this table gave, on the average, 5.4 percent lower volumes. Tree measurements were obtained as a part of the study of volume and growth on the cut-over lands in the Lake States.

Minnesota-Wisconsin 1930

Diameter breast high	Total height of tree - feet: 10	15	20	25	30	35	40	45	50	55	60	Merch. volume	Basis
Inches	Volume - cubic feet											Percent	Trees
1	.05	.07	.09										27
2	.15	.22	.28	.34	.40								58
3		.46	.59	.73	.85	.98							47
4			1.00	1.22	1.45	1.66	1.89	2.11				68	44
5			1.54	1.86	2.19	2.51	2.84	3.18	3.51	3.83	4.15	81	33
6				2.57	3.06	3.54	4.02	4.51	4.99	5.47	5.90	86	18
7						4.75	5.37	6.00	6.62	7.23	7.83	90	3
8						6.17	6.92	7.69	8.48	9.23	10.00	92	6
9							8.64	9.64	10.5	11.5	12.5	93	3
10							10.4	11.6	12.8	14.0	15.3	94	
Basis	35	47	43	47	25	21	10	7	2	1	1		239

Average deviation: ± 6.7 percent   Aggregate difference: -0.45 percent

Total volume includes stump, stem, and top with bark.
Merchantable volume expressed in percent of total volume includes the main stem above a one-foot stump to a top diameter of 3 inches inside bark.
Block indicates range of field data collected in Minnesota and Wisconsin.

No. 41   February 1931

MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

LAKE STATES FOREST EXPERIMENT STATION 1/
University Farm, St. Paul, Minnesota.

Volume of Second-Growth Norway Pine
Board Feet - International (1/8") Rule

Tree measurements obtained as a part of the study of volume and growth on the cut-over lands of Vilas, Oneida and Bayfield Counties, Wisconsin, form the basis for the following volume table. The measured trees occurred in pure and mixed stands as they were found along the survey strips.

Wisconsin   1931

Diameter Breast High	Merchantable height of trees in 16.3 ft. logs											Basis
	1	1½	2	2½	3	3½	4	4½	5	5½	6	
Inches	Volume - board feet											Trees
7	9	21	33	46								18
8	11	24	37	51	64							23
9	15	32	48	62	76	89						18
10		40	55	70	86	102	120	144				27
11		46	64	83	102	122	142	166				22
12			75	100	126	150	173	195	215			14
13			84	113	144	174	200	228	255	280		10
14			95	134	170	204	240	270	300	330		11
15				154	200	240	275	310	342	380	428	12
16				177	230	275	318	355	390	435	490	9
17				200	260	310	355	400	440	490	550	10
18						340	390	440	490	545	600	7
19						380	435	495	550	610	670	3
20							485	545	600	670	740	7
21							530	600	660	735	800	5
22							580	650	720	795	870	2
Basis	4	10	41	27	11	17	17	21	22	22	6	198

Average deviation: ± 8.4 percent.   Aggregate difference: -0.028 percent

Stump height, 1 foot: top diameter inside of bark, 5 inches.
Block indicates the range of field data.

March 1931

1/ Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · FOREST SERVICE

No. 43

Volume of Second-Growth Norway Pine - Board Feet, Scribner Dec. C

Tree measurements obtained as a part of the study of volume and growth on the cut-over lands of Vilas, Oneida, and Bayfield counties, Wisconsin, form the basis for this volume table. The measured trees occurred in pure and mixed stands as they were found along the survey strips.

Wisconsin 1931

Diameter breast high	Merchantable height of trees in 16.3-foot logs: 1	1½	2	2½	3	3½	4	4½	5	5½	6	Basis
Inches	Volume - board feet											Trees
7	2											18
8	2	3	4									23
9	2	3	5	6	7							18
10	3	4	5	7	8	10	11					27
11		4	6	8	10	12	13					22
12		5	7	9	11	13	15	17				14
13			8	10	13	15	17	19	21	23		10
14				12	15	18	20	23	25	27		11
15				14	17	20	23	26	29	31	34	12
16					19	22	26	30	33	36	39	9
17					22	26	30	34	37	40	44	10
18						29	33	37	40	44	48	7
19							37	41	45	49	53	3
20							41	46	50	54	59	7
21							45	50	55	59	65	5
22								54	59	65	70	2
Basis	22	25	33	10	14	19	17	14	30	12	2	198

Average deviation: ±8.9 Aggregate difference -0.03 percent

Volume includes main stem above a one-foot stump to a top diameter of six inches, inside bark.

Block indicates the range of basic data.

March 1931

MAINTAINED AT ST. PAUL 1, MINNESOTA, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · FOREST SERVICE

No. 44

Spring Fires on the Jack Pine Plains

Spring fires on the jack pine plains of the Lake States are common and burn over many thousands of acres each year. In many quarters such fires, occurring as they do before growth starts, are believed to do little damage. The following figures, secured four months after such a fire, indicate that this is not the case.

Forest Type: Open, uneven aged jack pine; 6" to 38' in height; 0 to 10" in diameter (4-1/2' above the ground); 1 to 40 years of age; merchantable stand about 1-1/4 cords per acre.

Date of Fire: April 15, 1931.

Time of Fire: 2 to 3 P.M.

Conditions prevailing: Temperature - 68°; depression of wet bulb - 18°; relative humidity - 24%; average moisture content of litter - 9.4%; wind direction - southeast; wind velocity 6' above the ground - 2.9 miles per hour , 30' above the ground - 8 miles per hour; weather - clear; fire hazard - high; trees - dormant.

Summary of Damage

	No damage	Slightly scorched	Moderately scorched	Fully scorched	Burned (dead)
	Percent	Percent	Percent	Percent	Percent
0 to 2' high.............	1	0	0	0	99
2 to 7' high.............	1	1	1	1	96
7' high to 4" diameter...	0	27	31	18	24
4" in diameter and up....	3	78	15	4	0
Percent of total number	1	11	5	3	80

In other words, early spring fires on the jack pine plains, such as the one recorded, which was typical, kill about 80 percent, and more or less seriously damage about 90 percent of the stand. The greatest damage done is to small trees or reproduction. Spring fires may cause little or no damage to merchantable trees but they are responsible for lack of reproduction in older stands, thus jeopardizing the future of the forest.

December 1931

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 45

Helping Nature to Seed the Forest

In this age when reduction in the cost of production is diligently searched for in every direction, foresters must also seek to develop cheaper methods of timber growing. The universally accepted procedure of replacing an old forest with a new one is by planting.

During last summer, the Experiment Station attempted to assist nature in reestablishing a forest by the use of an ordinary farm disk harrow. One area selected for this experiment proved very successful. An account of it may, therefore, be interesting.

A 3-acre plot was selected on the Chippewa National Forest in an old Norway pine stand. The ground was practically devoid of any young trees. This plot was disked in the autumn of 1930 at the time the seeds were falling. A year later, in the fall of 1931, an examination was made of the disked and the adjoining undisked areas. On the disked area over 15,000 1-year-old seedlings per acre were present, while on the adjoining undisked area only 2,000 seedlings.

To prove that the abundant reproduction is due to disking, the seed was sown at staked spots on the disked and undisked soil. One year later, on the disked soil, there was one seedling for every 35 seeds sown and on the undisturbed soil one seedling for every 50 seeds sown. Apparently about 97 percent of the seed failed to germinate from one or another cause. On the disked soil there was one dead seedling in every five, while on the undisked soil there was one dead seedling in every two. Disking improved the chances of survival.

The disk, by cutting up the sod and shrubs in the ground, lessened the competition of the under-growth and helped the seedlings to survive the dry summer. The seedlings on the disked soil were found most numerous in the bottom of the narrow furrows made by the disk. Evidently the furrows provided not only better conditions for germination and survival but also protected the seed from birds and rodents. The cost of this method of seeding the ground is estimated at about 75 cents per acre. As contrasted with \$6 to \$10 for planting, the method was a distinct practical advantage wherever it can be used effectively.

December 1931

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA
No. 46

Is Light Important Immediately After Germination?

It is generally assumed that the growth of seedlings during the period they are drawing their nourishment from the food stored in the seed is independent of light. It was thought that it is only later in life, when the stored food is exhausted, that the plant becomes entirely dependent upon food manufactured by its own green leaves under the influence of light.

Recent experiments conducted by the Station indicate that sunlight is an important factor in the life of the young plants long before its food stored in the seed is exhausted. If this proves to be generally true, then it may modify to some extent our forest nursery practice, explain the more rapid growth of young seedlings in openings, and enable us to understand better the needs of the seedlings in their early life.

Although the experiments were conducted in the greenhouse and laboratory with seed of common corn, the results are probably equally applicable to all other plants, including forest trees. Corn seed germinated in weak light and corn seed germinated in full sunlight showed a marked difference in their behavior. The seedlings which came up in full light utilized the stored food and grew far more rapidly than those in subdued light. When, however, the seedlings were grown in different light intensities but at the same temperature, no difference in either growth or the rate of utilization of the stored food material was detected.

The natural conclusion seems to be that it is not light as such that causes this stimulation in growth but the higher temperature that invariably accompanies stronger light.

Sunlight, through its action in warming the air and soil, tends to hasten the utilization of the kernel and the ultimate shedding of the seed coat, after which the seedling is comparatively free from danger of destruction by birds, mammals, and probably even damping off.

Since the more critical period in the life of a tree seedling is from germination until the seed coat is shed, the more rapidly the seedling can pass through this period the greater are its chances for survival.

December 1931

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota.

Test of Portable Hand Power Fire Pumps

The increasing use of water in fire suppression has led to the widespread use of portable hand power pumps. To determine the relative merits of the various types in use, comparative tests were made at the Michigan Forest Fire Experiment Station in 1931, conducted in cooperation with the Michigan Department of Conservation.

Pumps Tested.

1. Galvanized iron knapsack tank with single action trombone pump.
2. Galvanized iron knapsack tank with built in single action plunger pump.
3. Reinforced copper knapsack tank with built in diaphragm pump.
4. Upright cylindrical galvanized iron tank with built in single action plunger pump.
5. Galvanized iron knapsack tank with built in double action plunger pump.

Results of Tests.

	Pump Number									
	1		2		3		4		5	
Weight:										
Empty	8.4	Lbs.	12.8	Lbs.	15.4	Lbs.	15.3	Lbs	14.0	Lbs.
Full	45.9	"	53.1	"	46.2	"	53.5	"	46.0	"
Capacity:										
Rated	5	Gal.	5	Gal.	3.5	Gal.	5	Gal.	4	Gal.
Effective	4.4	"	4.5	"	3.6	"	4.1	"	3.6	"
Gross Weight per Gal.	10.5	Lbs.	11.7	Lbs.	12.7	Lbs.	13.0	Lbs.	13.0	Lbs.
Number of Strokes:										
Average per Gal.	42		36		58		34		36	
Discharge:										
Average per Min.	.87	Gal.	1.2	Gal.	.63	Gal.	1.17	Gal.	1.47	Gal.
Time to Exhaust:										
Average	5.0	Min.	3.8	Min.	5.8	Min.	3.5	Min.	2.4	Min.
Range:										
Average Normal	26	Ft.	25	Ft.	28	Ft.	35	Ft.	22	Ft.
Maximum	42	"	40	"	40	"	50	"	40	"
Vertical	26	"	30	"	36	"	33	"	34	"
Per cent of effective capacity delivered in 2" circle at:										
10"	82.0	%	57.6	%	95.4	%	56.6	%	66.3	%
20"	24.6		13.7		58.3		19.8		20.2	
30"	7.7		4.8		12.1		9.0		6.4	
40"	0.7		.3		.3		3.2		Trace	
Character of stream delivered:	Intermittent		Fluctuating		Steady		Fluctuating		Fluctuating	

December 1931

*Maintained by the U. S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota.

Comparative Merits of Different Portable Hand Power Fire Pumps.

The following five most commonly used fire pumps were tested by the Station in 1931, conducted in cooperation with the Michigan Department of Conservation:

1. Galvanized iron knapsack tank with single action trombone pump.
2. Galvanized iron knapsack tank with built in single action plunger pump.
3. Reinforced copper knapsack tank with built in diaphragm pump.
4. Upright cylindrical galvanized iron tank with built in single action plunger pump.
5. Galvanized iron knapsack tank with built in double action plunger pump.

Fire pumps No. 1 and No. 3 are operated while on the back of the operator which makes possible the most effective and economical use of their contents. Pumps Nos. 2, 4 and 5, on the other hand, must be set down when operated, which results in a loss of time and waste of water, since the tendency is to attempt to cover too much ground from one place.

Pump No. 1 is the lightest and has the greatest effective capacity per unit weight, but is somewhat less rugged than the others and the trombone pump with which it is equipped makes it awkward to transport and subject to damage. While the stream delivered is intermittent, it fluctuates but little and is readily directed and effective at normal range.

Pump No. 2 is rugged and handy to transport. It has a relatively high effective capacity in relation to weight, but the stream delivered fluctuates widely, which results in considerable waste.

Pump No. 3, while heavier than Pump No. 1 and smaller in capacity, lasts longer and delivers a steady stream with a minimum of waste. The volume of water delivered, however, owing to the size of nozzle with which it is equipped, is too small to be generally effective. While rugged in construction the protruding pump handle makes it awkward to transport and subject to damage.

Pump No. 4 has no particular advantage except a slightly longer range. On the other hand, it delivers a fluctuating stream, is heavy and awkward to carry and, hence, not suited to field use.

The chief advantage of pump No. 5 lies in its double action pump which tends to minimize the fluctuation of the stream delivered and thus reduce waste. Its high rate of discharge and small capacity tank, however, make it short lived.

December 1931

*Maintained by the U. S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA
No. 49

The Growth of a Gully

In non-glaciated southwestern Wisconsin and the adjacent corners of three other states, there is a sharp relief and a general difference in elevation of 500 to 600 feet between tablelands and river bottoms. As a result there are innumerable small narrow valleys in which farming is carried on.

The cutting of a gully usually begins at the lower end of one of these valleys, due to the unnatural quantity of run-off water from fields and pastured areas. Once started, a waterfall is created at the active head of the gully, which, by cutting away the loose sub-soil and thereby undermining the heavier surface layer, causes the gully to eat back into the valley land very rapidly. The highest activity is reached when the gully is approaching its greatest possible length in deep soil, and when branches have worked from the main gully into the slopes on both sides. After that a slowing of the soil-removing process sets in, but the main head and the equally important "side heads" still continue to extend their reach. This too is finally checked as these heads reach the slopes, where the soil becomes thin or is so filled with coarse rock fragments as not to be readily eroded.

By this time the gully has eaten away all of the best soil of the valley, and its arms spread into each little side drainage or depression, like the branches of a tree. The best part of the valley farm has been bodily removed, all of the good soil carried away to distant places by the streams, and the remaining fields have been so broken up into small units that management becomes very difficult. The best that can be hoped is that active erosion will now largely cease, that the points and "peninsulas" that have been left between the gully branches will tend to wear down, and that the steep walls of the gully will flatten out sufficiently to make possible a growth of trees or sod. Unfortunately, up to this point, planting of any kind on the gully walls is practically useless. The former field area becomes at best a piece of poor, rough pasture.

Gully formation is not a process by which the fertility and soil of a farm are slowly lost but is literally a cataclysm. For example, one large gully in Wisconsin advanced at a rate of 500 feet per year between 1923 and 1929. At the same time the many branches developed nearly 7,000 feet of smaller gullies. It reached a depth of 50 feet in its middle sector. Four hundred thousand cubic yards of soil were carried away at a rate of more than 40,000 cubic yards per year during the greatest activity. Sixteen acres of top soil were removed and at least 25 acres rendered useless. Since 1929 the gully has "quieted down," only about 27,000 cubic yards of material having been removed, while nine of the branches showed an average advance of only 65 feet. This gully is still not beyond control, but it could have been entirely prevented before any serious damage was done at a fraction of the cost which must now be incurred to "save" the farm.

December 1931.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota.

The Future of Aspen in the Lake States.

The enormous acreage of aspen in the Lake States (some 22 million acres), its small utilization, its universal decadence and short life, make many people look with justified doubt upon aspen as a crop of economic importance. The possibilities of converting aspen by artificial means to pine and spruce are seriously discussed. In this discussion the tendency toward natural conversion of aspen to other types, particularly hardwoods, is often overlooked.

The forest surveys conducted by this Station in Wisconsin, Michigan, and Minnesota, covering more than one million acres of aspen land, throw some interesting light upon the present composition of the aspen stands and, hence, their probable future.

To begin with, there are few aspen stands that are 100 per cent pure. Most of the "pure" aspen stands contain only from 50 to 65 per cent aspen and many stands classed as aspen contain as little as 30 per cent of that species. This refers to trees one inch or over in diameter. The other species in mixture are either inferior hardwoods (paper birch, red maple, jack oak, ironwood and black ash), which make up from 10 to 30 per cent of the stand or the better hardwoods (sugar maple, yellow birch, basswood, red and white oak, white ash, and elm). These, too, may form from 10 to 30 per cent of the entire stand. And finally conifers (jack, white and Norway pines, balsam, spruce and, in some places, hemlock) that may comprise from 4 to 10 per cent of the total stand.

Since all these species are much longer lived trees than aspen, they will eventually, if not disturbed by fire, take the place of the aspen.

The character of reproduction, that is, trees below one inch in diameter, may serve as an indication of the future composition of the aspen stands. The striking fact is that most of the seedling reproduction in aspen stands is not aspen. On loamy soils, in Wisconsin, over 50 per cent of the entire reproduction was found to be of hardwoods, principally sugar maple with some small amount of white pine and spruce. On the sandy soils, the better hardwoods may form only one-fifth of the entire reproduction, but the inferior hardwoods are quite prevalent and there is usually a sprinkling of jack pine or white pine, and in wet places balsam fir or spruce. This would indicate that, on the heavier soils, aspen is being changed naturally into hardwoods and the change is relatively rapid. Considering that over millions of acres there may be found upwards of 200 trees per acre of better hardwoods in the present aspen stands, the conversion should be well advanced within the next 25 to 50 years. On the sandy soils, the conversion is toward jack, Norway and white pine and, in some places, balsam, but this process is slower than the conversion to hardwoods.

Fires or clear cutting of aspen on either sands or loams may throw it back into pure aspen.

If the aspen stands are left to nature and not disturbed by clear cutting or fires, they may, within another generation, present an entirely different silvicultural and economic aspect. The presence of a large number of better hardwoods in many of the aspen stands augurs well for their future.

December 1931.

*Maintained by the U. S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA
No. 51

Jack Pine - Pulpwood or Sawlogs

It has been generally assumed that jack pine reaches its best development at about 50 or 60 years, at which time the trees should be cut. At such an age, jack pine on an average reaches a diameter of 7 or 8 inches and a height of about 55 feet. If this is the limit of growth for jack pine, then it should be grown chiefly for pulpwood and not for sawlogs, and clear cutting would seem to be the most practical method of utilization.

If, on the other hand, jack pine is capable of increasing its growth after 50 or 60 years, when the stand is opened up, it should be possible to grow jack pine to sawlog size in about 80 or 90 years and instead of clear cutting, the stand should be cut selectively or partially.

To test the ability of jack pine to respond to thinnings at the age of 50-60 years, the Station established 8 permanent sample plots -- 4 in a 60-year old overstocked stand on the Superior National Forest, and 4 in a 55-year old understocked stand on the Chippewa National Forest. These plots were cut over in various ways in 1926 and remeasured in 1931. In each set one plot was left uncut for comparison.

Practically all trees released by cutting in the 60-year old overstocked stand, except the very small suppressed **ones**, accelerated their diameter growth. This growth was from 30 to 90 per cent greater than on similar trees on the untreated plot, the increase depending largely upon the degree to which the stand was opened. If this rate continues for 25 years, the average trees will then be about 10 inches in diameter with many trees much larger in size.

The understocked 55-year old stand behaved somewhat differently in that the large trees, which already had ample growing space, were but little affected by the thinning. However, medium sized trees, when released by cutting, accelerated their diameter growth fully as much as those in the dense overstocked stand.

Although time alone can tell how long the increased rate of growth will continue, the early acceleration in diameter growth brought out by these experiments emphasized the possibility of some kind of a partial-cutting method in 55-60 year old jack pine.

In dense stands of this age where the growing of sawtimber is the goal, the removal of small sized pulpwood will bring about use of wood which would otherwise be lost and, at the same time, greatly benefit the remaining stand. In more open stands where the trees are larger, it may be better practice to harvest part of the sawlogs, leaving a stand of medium sized trees for future growth.

May 23, 1932

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Growing Bigger and Better Aspen

A drastic revaluation of forest trees is taking place in the minds of foresters and lumbermen. Just as the despised jack pine of yesterday is accepted as a valuable tree today, so aspen, the weed tree of today, is beginning to acquire market value in some sections of the Lake States. With some 22 million acres of aspen in the Lake States and with its growing economic importance, it becomes advisable to devote some of our efforts toward the improvement of aspen instead of trying to eradicate and replace it with other forest trees.

An attempt to improve an aspen stand on the Chippewa National Forest was undertaken by this Station in 1926. The common commercial practice is to cut all aspen trees which are merchantable. This leaves a ragged stand of small and defective trees encumbering the ground, practically none of which are valuable for a second cut. The Station sought to determine whether the aspen stand could be improved and its rate of growth increased if it were cut by some selective method. Two plots in a 38-year old stand were cut selectively, removing 30 and 50 per cent of the crown areas. A third was left uncut. When remeasured in 1931, diameter growth on the plots from which 30 and 50 per cent of the stand was removed was found respectively to be 60 and 80 per cent greater than on the uncut plot.

By judicious thinnings, started at 20 years of age when fuel wood can be removed, and repeated at 30 to 35 years of age when pulp and box bolts may be cut, the growth of aspen can be greatly stimulated and trees of sawtimber size produced much earlier and of much better quality than in unthinned stands. Such treatment will pay if the aspen is growing on good soil and if a local market is available.

Incidentally, if it is desired to convert aspen to a forest of maple and yellow birch or even spruce or pine, thinnings and partial cuttings favoring those species will hasten the change. The surest way to perpetuate aspen on heavier soils is to cut it clean.

May 23, 1932.

*Maintained by the U.S.Department of Agriculture at St. Paul, Minnesota in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA
No. 53

Aspen and Birch Follow Pine Cutting in Northeastern Minnesota

In the past cuttings in pine stands in northeastern Minnesota, most of the merchantable trees were removed. In the majority of cases this amounted to practically clear cutting of the pine. It was expected that such cutting would provide ample light and space for second growth pine. The results, however, proved disappointing. Instead of reproduction of pine, the young growth that took possession of the ground on cut-over land was largely aspen and paper birch. This proved to be true particularly on the heavier soils well suited to the growth of these hardwoods.

The Station in 1931 made a study of cut-over pine lands on the Superior National Forest and vicinity. These areas were sampled by some 140 plots and an additional 60 plots were laid out in uncut stands as a comparison. On the 89 plots in jack pine stands which originally contained less than 10 per cent of aspen and birch in mixture, the reproduction is summarized below:

Degree of cutting in per cent of basal area removed	Number of seedlings, sprouts and suckers per acre	
	Conifers 1/	Hardwoods 2/
Uncut	476	604
41-70%	929	1804
71-100%	509	2376

1/ Jack pine, Norway pine, white pine, spruce, balsam fir.
2/ Aspen, paper birch, red maple.

This would indicate that on the soils favorable to the growth of aspen and birch, heavy cutting of jack pine resulted in an enormous increase in these inferior hardwoods in the second growth. However, the suckers and sprouts were much less numerous where a lighter cut was made in the original stand and the conifer reproduction was considerably better.

But lighter cutting alone may not insure adequate restocking of cut-over pine lands with desirable conifers. It may be necessary to release young conifers by cutting out the aspen suckers. Also some cultural operation which would stir up the soil may be necessary to make the soil more receptive to the germination of pine seedlings.

May 23, 1932

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 54

How to Cut Black Spruce

Black spruce in the northern Lake States is widely distributed in mixture with other species, but as a type is limited chiefly to swamps. On the basis of a study of black spruce in northeastern Minnesota, it appears that the two most important characteristics of such swamps are slow growth and the presence in the stand of trees of all ages, from one-year-old seedlings to veterans of 200 years. This uneven-aged character of the black spruce stands practically insures a new forest of spruce at any time the old trees are removed. A study of old cuttings in black spruce swamps on the Superior National Forest on some 80 different sample plots showed that four-fifths of all black spruce areas examined support a reasonably good second growth regardless of how the stand was cut.

From the standpoint of securing natural reproduction of black spruce, then, it seems that either clear or partial cutting may be used in black spruce swamps. From the standpoint of continuity of production, partial cutting is more desirable, provided the remaining stand is safe against loss from windfall. Clear cutting precludes the possibility of a second cut for the next 75 or 100 years. Partial cutting, however, may provide a second cut at a comparatively short interval if the stand is protected against the wind. In such localities, partial cutting of black spruce is preferable to clear cutting.

The trees remaining in a partially-cut stand were found to increase their growth. Some 54 black spruce trees were studied 15 years after logging in this stand. More than half of these trees showed increased growth in diameter although many of them were over 100 years old when released. The rate of growth of these trees was 81 per cent greater and the average diameter growth for all trees left was 34 per cent greater during the 15 years since cutting than during the same period of time before cutting.

The general conclusion from the study is that both clear cutting and partial cutting results in abundant natural reproduction of black spruce in swamps; that in sheltered places where the danger of windthrow is slight, partial cutting has the added advantage of providing a second cut in a comparatively short time; and that trees left after partial cutting put on a greater rate of growth.

May 23, 1932

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Neglected Plantations Seldom Successful

"Behold a sower went forth to sow; and when he sowed some seed fell by the wayside and were devoured by fowls; some fell upon stony places where they sprang up but withered in the sun because they had no root; some seed fell among the thorns and the thorns sprang up and choked them out; and some fell on good ground and brought forth fruit."

This parable has a direct application for those engaged in large-scale forest planting in this region. All too often the forest planter considers his job done when the trees are set out in the field, and his calculation of costs ends with this item. Yet, this is really only the beginning of reforestation work.

Studies by the Station show that sod, hazelnut brush, and aspen present great hazards to forest seedlings which may and often do greatly curtail, if indeed they do not entirely destroy, the future usefulness of forest plantations. White grubs, which infest sod, feed on the roots of young trees and when a drought occurs the crippled roots are unable to keep the plant alive. Hazelnut and aspen literally choke out young conifers, often even after they have obtained a height of 20 feet or more.

To illustrate the point, two examples from the many plantations examined by the Station may be cited. A pine plantation was established 15 years ago on land burned clean the year before planting. Today only 20 per cent remains pure pine, 55 per cent is a mixed forest of pine and aspen, and 25 per cent has reverted entirely to aspen and brush. Another coniferous plantation, established about the same time in a hardwood stand, has completely disappeared except for an occasional lath used to mark the trees.

In any large scale forest planting, provision should be made for care of the plantations, for if aspen and brush are allowed to crowd out the desired trees the entire effort in planting becomes fruitless.

May 23, 1932.

*Maintained by the U.S. Department of Agriculture at St. Paul, Minnesota in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA
No. 56

Dryness - Key to Storage of Pine Seed

The riddle of seed storage appears to have been solved by the results of Norway pine tests which have completed their fourth year, and of two tests of white pine seed storage which have run 3 and 2 years respectively. In the case of seeds of this type, preservation of the germinability depends on having the seed thoroughly dried before storage and sealing them against moisture absorption during storage. Storage at a low temperature has everything to recommend it, as has long been believed, but the seeds seem to stand much greater fluctuations in temperature during storage if their moisture content is low enough.

This is better understood when it is realized that both moisture and heat are necessary to respiration, and it is through respiration that the energy of the seed is "burned up" during a long period of storage, although, if very high temperatures are experienced, the seed may spoil through the rancidifying of their fats. Respiration almost ceases below about 40 degrees F. It also drops off rapidly, in the case of white pine, at moisture contents below about 12%, but as there is no sharp line here, it is a matter of bringing the moisture as low as possible consistent with safety. This appears to be at about 6% moisture for white pine seed, and at slightly less than 5% moisture for Norway pine seed, but the exact optima need to be determined by further tests. The above moisture contents correspond with complete drying in atmospheres of 30% and 25% relative humidities, respectively.

In other words, if white pine seed is extracted by opening the cones in the sun, it is desirable to expose them in an artificially warmed room long enough to be certain that they have dried as much as possible at an atmospheric humidity of 30%. Such a humidity is not difficult to maintain when the weather has become frosty. Close control of the moisture need not be attempted until the seeds have dried for some time, when the air moisture may be brought to 30% relative humidity and maintained at that point long enough to permit the final adjustment to be made. In a room kept at 70° F., such a humidity means a psychrometer wet-bulb depression of 17°.

When either white pine or Norway pine seed is extracted by artificial heat, the chances are good that the seed will be dried enough to keep well. Moisture tests may be made to see whether the drying process has gone far enough for the best results, or possibly too far. It has actually been shown in large-scale operations that kiln-extracted white pine seed was greatly superior to sun-extracted seed after periods of 1 to 3 years, apparently for the reason that the sun-extracted seed was put into storage with too much moisture.

In the Experiment Station tests, white pine seed has been kept for 3 years with its vitality unimpaired when both low moisture and low temperatures were used, and with only slight loss of the properly-dried seed at any temperature up to that involving normal summer heat. Norway pine dried at 20-25% relative humidity has lost none of its vitality after 4 years when kept at 32-34° F., but the seed stored in a cellar has lost one-seventh and that in a shed more than one-half of its original germinability.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota.

How Soon After a Fire Can Damage be Determined?

It has long been realized that the damage resulting from a forest fire cannot be accurately determined immediately after the fire except where the destruction is complete. Few data are available, however, as to just how much time must elapse before a reliable estimate can be made. To throw some light on this question repeat tallies at intervals of one month, three to four months, and twelve to seventeen months were made on a number of experimental fires in jack pine at the Michigan Forest Fire Experiment Station** in 1931 and 1932.

All plots tallied a month or less after burning showed heavy later losses in all of the smaller size classes, while the plots tallied three to four months after burning showed little or no later loss. It would appear, therefore, that three or four months should be allowed to elapse after a fire before damage estimates are made.

As a rule, trees under two feet high die at once if damaged at all, while trees over four inches d.b.h. recover if not completely scorched. Trees between over two feet high and under four inches in diameter usually die if 90 percent or more of the crown is killed. It would appear that mortality is due primarily to crown damage since in no case was death traceable to butt injury alone except where, due to repeated burning, the tree was mechanically weakened to a point where it broke off or blew down.

The above conclusions apply only to jack pine since the fire resistance of different species of trees differ.

February 1, 1933.

*Maintained by the U.S.Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

**Maintained in cooperation with the Michigan Department of Conservation.

LAKE STATES FOREST EXPERIMENT STATION 1/
University Farm, St. Paul, Minnesota

Fire Damage as Affected by Season of Burning

That fires at different seasons differ in the amount and character of damage they do has long been the contention of various observers. To throw some light on this question a series of four adjoining plots at the Michigan Forest Fire Experiment Station 2/ were burned over at various times during 1931 and the resulting damage noted. The results support the above contention and point out the ways in which fires at various seasons differ.

The experiment was carried out in an open stand of all-aged jack pine and the conclusions reached may not be applicable to other types. The results of other fire damage studies under way, however, tend to substantiate them for jack pine.

Season of burning	0.0'- 1.9' height	2.0'- 6.9' height	7.0' height -3.9"dbh.	4.0"- up dbh.	All sizes
Early spring	99	95	26	0	84
Late spring	95	76	5	0	73
Summer	82	88	40	2	68
Fall	64	80	26	0	57
All seasons	86	89	26	2	72

As is to be expected, mortality in general is greater in the smaller size classes and progressively less as size increases, regardless of the season. It will be noted, however, that in the smaller size classes mortality was highest in spring while in the larger size classes a marked increase in mortality was later evident, particularly in summer.

In other words, spring fires in jack pine are particularly destructive of seedlings and saplings but do little damage to merchantable timber. Summer fires, on the other hand, are less completely destructive of small trees but do considerable damage to trees in the larger size classes.

The reason for this is that spring fires, as a rule, make a complete burn but are confined to the surface litter and hence are not hot enough to damage seriously the larger trees though killing most of the small ones. Summer fires, on the other hand, burn deeper, are hotter and are more apt to crown, and hence do more damage to large trees. Both summer and fall fires, however, are inclined to be spotty owing to the presence of green vegetation, thus allowing a larger proportion of the small trees to escape destruction.

February 1933

1/ Maintained by the U. S. Department of Agriculture, at St. Paul, Minnesota, in cooperation with the University of Minnesota.

2/ Maintained in cooperation with the Michigan Department of Conservation.

LAKE STATES FOREST EXPERIMENT STATION[1/]
University Farm, St. Paul, Minnesota

The advantages and disadvantages of various methods of slash disposal are brought out by the following summary of results secured in a study made at the Michigan Forest Fire Experiment Station[2/] in connection with a fuel wood operation in open, all-aged jack pine. The stand in question was cut to a 6" diameter limit and yielded, on the average, 5.2 cords per acre. Stands of this character are typical of much of the poorer cut- and burned-over pine region of the Lake States.

	Cost of slash disposal per cord	Resulting fire hazard	Damage to advance growth
Piled and burned..................	$ 1.89	Normal	Moderate
Piled and left unburned..........	1.46	High	Slight
Swamper burned....................	.78	Normal	Slight
Lopped and left unburned.........	.32	High	Moderate
Broadcast burned..................	.15 (Est.)	Low	Extreme
Undisposed........................	....	Extreme	Severe

From the above it will be seen that: From the standpoint of damage to young growth -- swamper burning (or burning the slash as cut) and piling and leaving unburned are the most desirable; from the standpoint of resulting fire hazard -- swamper burning, piling and burning and broadcast burning are best; while non-disposal, broadcast burning and lopping are cheapest.

All things considered, swamper burning appears to be the most desirable method of slash disposal since the cost is moderate, the slash hazard is eliminated at once and but little damage is done to advance growth. This method also greatly facilitates the cutting up and removal of the merchantable material and stimulates close utilization.

Broadcast burning, while cheap and eliminating the slash fire hazard, is extremely dangerous and results in the destruction of most of the advance growth. On the other hand, if slash is left undisposed, a serious fire hazard is created which persists for a number of years and calls for special protection.

The costs given above should be taken as relative rather than absolute since, due to the open character of the stand, the amount of slash in proportion to the amount of merchantable material was abnormally large.

February 1933

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Technical Notes

No. 60

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Direct Seeding Can Sometimes Be Used in Reforestation

In some European countries direct seeding is a common method of reforestation. Several attempts have been made to establish forests by direct seeding in this country but only rarely has success been attained.

The Station has been working on this problem for three years and, in addition to the failures commonly obtained, there have been some surprising successes. Best results were obtained on the [illegible] National Forest where approximately twelve acres were sown last spring. The seeds were dropped in furrows and stepped on. In the fall there was an average of 2,800 seedlings per acre on the area sown. A two-acre strip was cultivated with a disk harrow and the seed sown broadcast on the disked soil. This strip had an average of 4,240 seedlings per acre in the fall. Jack pine seed mixed with small quantities of Norway and white pine and Norway and white spruce was sown. In the resulting stand, jack pine comprised 78 per cent and Norway pine 17 per cent, with 2, 2, and 1 per cent for the other three species in the order named. The cost of this work was approximately $1.95 per acre distributed as follows: seed $1.00, plowing $0.60, and sowing $0.35. Equally good results have been obtained elsewhere with Norway spruce and Norway pine.

The requirements for success appear to be: (1) suitable soil preparation, (2) sparse population of seed-eating birds and rodents, and (3) sufficient rainfall during the period of germination.

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LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota.

Release Cuttings Needed in Natural Second-Growth Stands

It is estimated that some 15 per cent of the 22 million acres of aspen-birch lands in the Lake States are restocking to conifers and an additional acreage is coming in to valuable hardwoods. In a large measure, these are areas where the quality of aspen is poor or where the future merchantability of this species is at least dubious. Nature will, if unimpeded, convert some of these areas into more valuable forests, but there is ample opportunity for the assistance of man. The expenditure of a dollar per acre for "cleaning" may change the entire history of a young forest.

This may be illustrated by a well-stocked young stand on the Superior National Forest. There were in this stand 3,000 trees per acre, mostly aspen and paper birch averaging 13 feet tall. There were also 2,500 spruce averaging 6 feet in height. The hardwoods were clearly dominating the spruce, but the latter, if given plenty of time, would eventually replace much of the aspen. The process, however, is very slow. It is certain that the conversion could be speeded up and the growth of the spruce stimulated greatly by the removal of a part of the aspen.

In other cases pine and spruce under aspen are actually decreasing in number as evidenced by another example. In this stand there were 1,014 hardwoods per acre averaging 40 feet tall and 265 conifers, chiefly white pine, 19 feet tall on the average. The conifers were distinctly outstripped by the hardwoods. Besides this evidence of suppression there were 108 standing dead pines per acre which undoubtedly had died because of aspen competition. On such areas release cuttings are absolutely essential if the pine is to be saved.

An experiment, established in 1905 in New Hampshire, in which hardwoods overtopping spruce were girdled, showed the volume growth of spruce to be over five times as great as in ungirdled stands. Release cuttings made to promote the growth of valuable species can thus be expected to yield a return on the investment and the time when costs will be paid back should obviously be much shorter than it will be with planting where it is necessary to start with bare land instead of trees already established.

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*Maintained by the U.S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 62

Growth of Hardwoods

Any authentic record of the growth that takes place in a forest partially cut is of interest. It is indicative of what forests can do under systematic forest practice.

A hardwood forest of sugar maple and hemlock in Oneida County, Wisconsin, was cut rather heavily in 1892. The logger, however, left standing at that time some 250 trees to the acre. Of these, 200 trees were from one to five inches in diameter, 40 trees from six to nine inches, and 10 trees from ten to sixteen inches in diameter. There were left in the larger trees some 1,200 board feet.

In 1932, or 40 years later, this forest was cut again. About 7,720 board feet were cut in the form of 200 trees per acre. In addition, a little over 1,000 board feet were left standing in healthy promising trees. Further, 1,300 board feet represented cull in the form of broken and defective trees. The total gross volume was, therefore, in round figures 10,000 board feet. If we deduct the 1,200 board feet left in 1892, the total growth in 40 years was 8,800 board feet. In other words, the forest grew at the rate of 220 board feet per acre per year. Allowing even 20 percent for cull, this represents a net growth of 176 board feet per acre per year.

If such growth is possible in a haphazard cutting (the cutting of 1892 was a trespass cutting), a greater net growth should be obtained under forest management.

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No. 63

Well Developed Stock Necessary for Successful Planting

It is now generally accepted that well developed stock is essential to successful planting. Poorly developed seedlings often result from crowding in the seed beds, although such damage may be minimized by sowing the seed in drills. A few concrete illustrations serve to bring this point home and suggest the value of grading stock before planting.

Some 2-0 Norway pine stock which was planted in the fall of 1931 on the Huron National Forest in Michigan showed the following variations in size:

	Length Inches		Weight Grams	
	Top	Root	Top	Root
Largest specimen.............	7.1	12.3	4.17	.95
Average......................	5.0	8.3	2.13	.49
Smallest specimen...........	3.2	6.0	.72	.22

Counts made in the summer of 1932 showed that 40 percent of all the trees which died were small plants with no sign of injury.

Another case of loss from poorly developed stock occurred among Scotch pine which had been broadcast sown in the seed beds and produced too thick a stand. The trees in the interior of the bed had not hardened off sufficiently and were quite susceptible to frost injury. One season after planting the survival of this stock as compared with well developed Norway pine planted in combination with it was as follows:

Stock	Percent survival			
	Growing	Living	Failing	Dead
2-0 Norway pine...........	93.7	5.3	0.3	0.7
2-1 Norway pine...........	98.2	1.2	...	0.6
2-0 Scotch pine...........	68.6	10.4	...	21.0

Other Scotch pine (of the same and other sources of seed) which were better developed in the nursery and were planted only a few rods away showed approximately the same survival as the Norway pine. In this case it may be said that poorly developed stock, which might better have been culled according to size, cost approximately 20 percent in dead trees.

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LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 64

How to Thin Young Norway Pine

Natural stands of Norway pine in the Lake States at the age of 20 to 25 years may contain as many as 5,600 trees per acre. Stands of this kind are too dense for proper development. Nature, given time enough, will thin such forests herself, but the process is very slow and growth is retarded. Nature can be helped by thinning.

In order to find out how such work should be done, the Station in 1927 thinned three plots, from one-tenth acre to two-tenths acre in size, in a 25-year-old stand of Norway pine on the Chippewa National Forest and left a fourth untouched for comparison. Trees were thinned to spacings of 6 x 6, 8 x 8, and 10 x 10 feet. In 1932 trees on these plots were remeasured. The results are shown in the table below:

Spacing	No. trees per acre		Five years' growth		
	Cut	Left	Diameter (Ave. tree in inches)	Height (Ave. tree in feet)	Volume (Cubic feet per acre)
Unthinned	...	3,620	.25	5.2	615
6' x 6'	4,415	1,254	.81	4.4	376
8' x 8'	3,500	710	1.03	4.4	311
10' x 10'	2,820	446	1.23	4.8	250

The outstanding facts as shown by the table are: Diameter growth varied directly with the degree of thinning. Height growth on the thinned plots was not as great as on the unthinned. The greatest increase in volume of wood per acre occurred on the unthinned plot since it had more growing trees than the others. Before the trees on the unthinned plot reach merchantable size, many will have died, hence much of this volume growth will be lost. The 10' x 10' spacing was so open that undesirable grass and shrubs have started to come in, while on the 6' x 6' spacing the crowns are already closing.

For practical purposes, therefore, the 8' x 8' spacing seems best since it gives ample growing space without opening up the stand to such an extent as to encourage the establishment of brush. Such stands, by the time they are ready to thin again, should contain merchantable products.

November 1933

LAKE STATES FOREST EXPERIMENT STATION
University Farm, St. Paul, Minnesota

Grading Seedlings

It is common practice in the Lake States to plant two-year old seedlings of [Nor]way pine in the field regardless of the state of development of the individual [pla]nts. Where the plants are uniformly well developed this seems to be a desirable [pr]actice, but frequently, because of crowding in the seed-bed, or for some other [rea]son, there is a considerable range in size of 2-0 stock. Perhaps the smallest [see]dlings should be put back in the nursery in transplant rows until they have [re]ached a better state of development.

In order to obtain specific information on this question a grading test was [mad]e on the Superior National Forest in the spring of 1933. Approximately 4500 [see]dlings were selected at random. Since there was no great difference in top-root [ra]tios of different sized plants, the stock was graded almost entirely on the basis [of] size into three groups: "large", "medium", and "small". In addition, a fourth [gro]up made up of damaged trees was culled in accordance with standard practice. In [the] sample selected, 21 per cent of the plants were "large", 41 per cent "medium", [33] per cent "small", and 5 per cent "cull".

Approximately 1000 of each of the first three classes were carefully planted in [th]e field. At the end of the first growing season -- which was a fairly favorable [on]e -- the plants were examined and classified into: "growing" (vigorous, thrifty [tr]ees); "living" (alive, but making no appreciable growth); "failing" (trees prac-[ti]cally certain to die); and dead trees. The results are shown in the following [ta]ble:

Grade	Growing		Living		Failing		Dead	
	No.	Per Cent of Total	No.	Per Cent of Total	No.	Per Cent of Total	No.	Per Cent of Total
Small	731	73	137	14	30	3	100	10
Medium	867	87	59	6	9	1	65	6
Large	894	90	54	5	11	1	40	4

The "small" trees are at a disadvantage in comparison to the other grades [und]er each classification. Especially under the heading "growing" trees, the [lo]west grade shows up rather poorly. The larger grades, on the other hand, have [do]ne exceptionally well.

These results are supported by studies made by the station of experimental [pl]antations established in 1931 on the Huron National Forest. The chief cause [of] loss in these plantings is attributed to small stock. Besides being spindly, [su]ch stock does not harden sufficiently to stand low temperatures when planted [in] the field.

Although it is too early to draw final conclusions, it would seem as though [gr]ading of seedling planting stock had considerable merit.

[No]vember 1933.

*Maintained by the United States Department of Agriculture at St. Paul, Minnesota in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 66

Solid Contents of Standard Cords

(Peeled Black Spruce Pulpwood)

Black spruce is the most abundant of the more valuable pulpwood species in the Lake States. It occurs in swamps throughout the northern part of the region where merchantable trees range from 6-9 inches in diameter breast high. The pulpwood, composed of round peeled bolts, is bought and sold by standard cords 4 x 4 x 8 feet (128 cubic feet of stacked wood). Frequently it is very useful to know the solid contents of a stacked cord in order to translate cubic-foot volume into terms of standard cords.

Cutting of black spruce on the Chippewa National Forest in Minnesota afforded an opportunity to obtain this information. Trees were cut into 8.3-foot bolts to a top diameter of 4 inches. The bolts were peeled and piled in stacks. The average diameter of all bolts in the piles was 5.4 inches, corresponding to an average diameter of trees of 7.0 inches. The following information was obtained on the basis of 40 carefully measured cordwood piles:

Number of bolts per cord	69.6
Percent solid volume	71.2
Cubic feet per cord	91.1

Statistical analysis of the above average figures showed that they can be safely used for the entire narrow range in diameter (6-9 inches) of merchantable trees.

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MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
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No. 67

Paper Birch - A Windfirm Tree

The destructive effect of wind upon forest trees has long been observed by foresters and woodsmen. Rarely, however, has the opportunity presented itself to obtain information on a large scale of the relative destructiveness of wind on different species of trees. This opportunity was presented on July 20, 1932, when a violent storm swept over half a million acres in northeastern Minnesota, nearly half of which was within the Superior National Forest. A wind velocity of 56 miles per hour was recorded at Ely, Minnesota, near the northern edge of the storm area.

Following the storm a study was made of the damage wrought by the wind. Damage was recorded on 508 tenth-acre sample plots. Fifteen percent of all trees over four inches in diameter were found to have been damaged in some manner. The taller trees, because they were more exposed to the wind and subject to greater leverage action, suffered the most. Of the damaged trees, nearly two-thirds were uprooted and an additional thirty percent were about equally divided between those leaning at such an angle that they will be sure to go down under the weight of heavy snow, and those broken off squarely below the crown.

The relative resistance to wind injury of the species most common to northeastern Minnesota, as determined by the study, is shown below, beginning with the most resistant:

1. Paper birch
2. Jack pine
3. Aspen
4. Spruce (black and white)

Over a fifth of all spruce trees were blown down or damaged whereas the injury to birch was only about one-third as great. Paper birch with its firm-holding root system, together with its general form and resiliency, seems best able to resist the force of the wind.

November 1933

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Volume of Sugar Maple
(Board Feet - Scribner)

The volume table presented below is based on data obtained mostly in northeastern Wisconsin and the Upper Peninsula of Michigan. The measurements were collected on commercial logging operations, on experimental selective cuttings, and in connection with a study of growth and yield. Both virgin timber and second-growth were included in the measurements.

Diameter Breast High (Inches)	Number of 16.3 foot logs: 1	2	3	4	Basis Number of Trees
	Volume - Board Feet				
10	31				4
11	40				17
12	50	84			22
13	61	102			31
14	72	123	157		25
15	85	146	189		33
16	98	169	221		31
17	111	192	253		34
18	126	219	287	340	34
19	140	244	322	381	24
20	156	270	360	423	16
21	172	299	397	470	28
22	189	328	437	520	33
23	207	359	480	568	28
24	226	390	522	622	23
25	246	424	567	676	18
26	266	460	616	732	20
27	287	496	670	793	10
28	308	532	720	852	10
29	330	571	769	914	5
30	351	611	820	980	5
31	373	649	868	1046	7
32	395	690	923	1108	4
33	417	730	984	1177	2
34	442	780	1054	1246	2
35	465	829	1140	1314	
Total					466

Based on form-class taper tables. Form class, which is the ratio between top d.i.b. of the first 16-foot log and the diameter breast high o.b., varied with diameter breast high as follows: F= 84 - .3/10D.
Stump height 2 feet. Merchantable log not less than 8 inches at top d.i.b. Top diameter variable. Merchantable cutting limit where the stem breaks up into large branches. Average deviation of tree volumes from table volumes ± 12 per cent.
Block indicates the extent of basic data.

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*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

Technical Notes

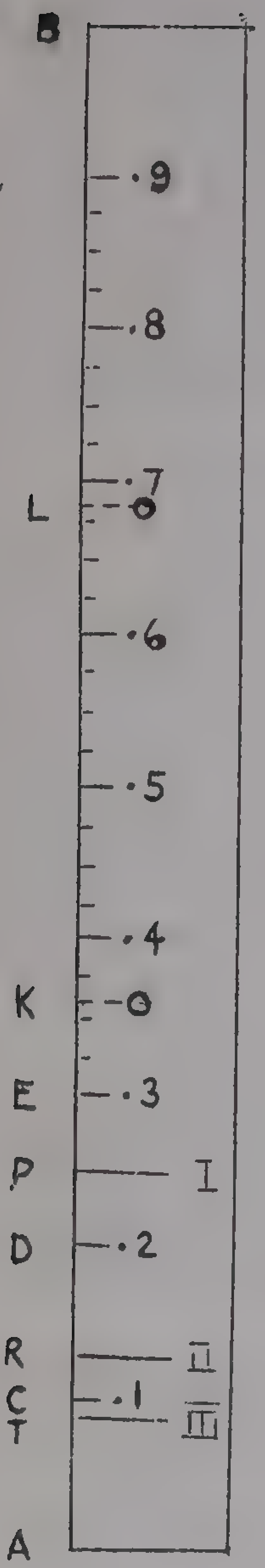
No. 69

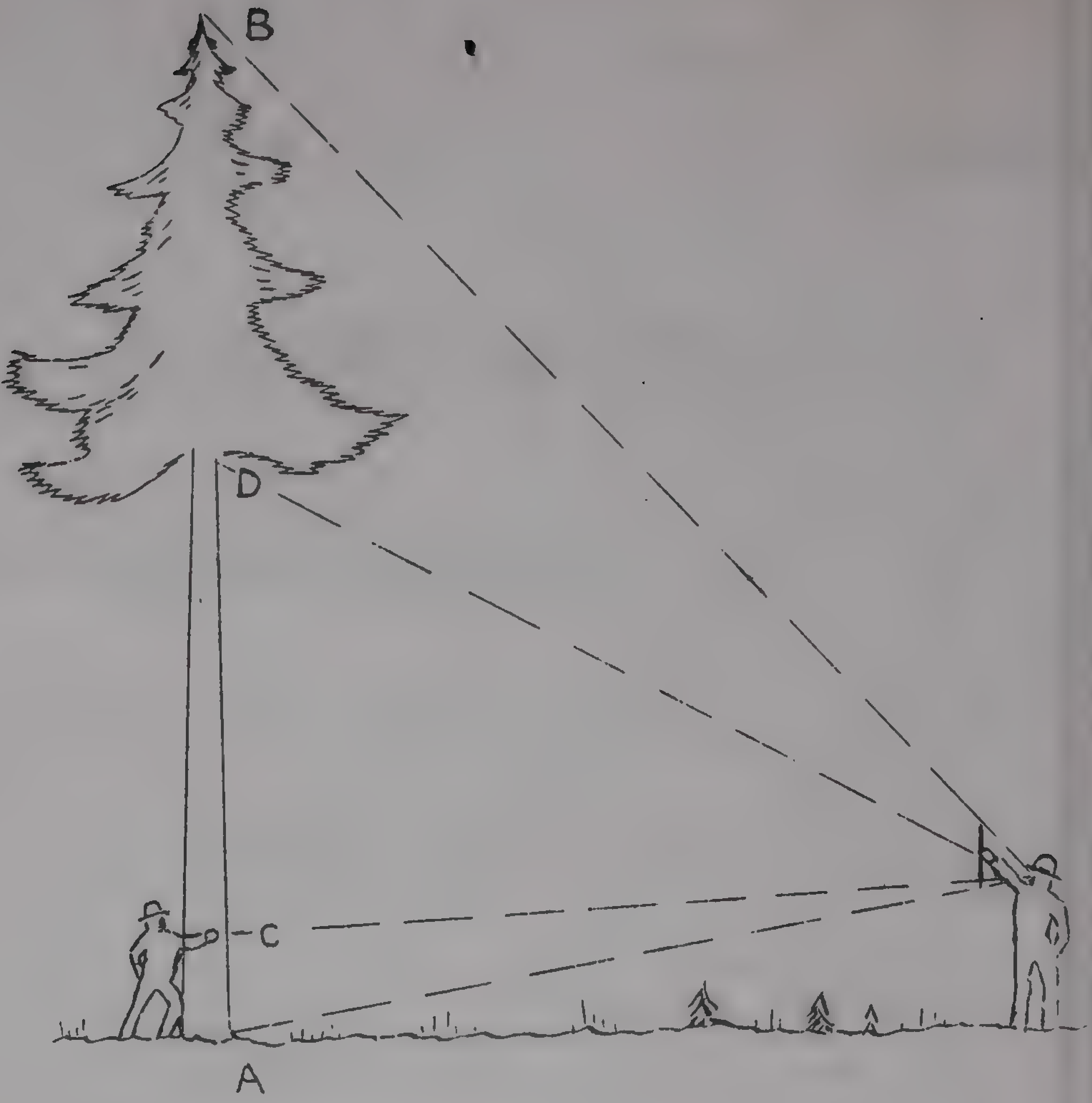
LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

THE LAKE STATES CRUISER STICK

November, 1933

*Maintained by the United States Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota





AB = 12"
AC = .1AB
AD = .2AB
AE = .3AB etc.

AK = .36AB
AL = .68AB
AP = .246AB
AR = .13AB
AT = .09AB

THE LAKE STATES CRUISER STICK

For some time there has been a need for a light-weight inexpensive cruiser stick for use on forest surveys in determining total or merchantable height or number of logs in a tree without the necessity of measuring distance. Many of the hypsometers on the market, although accurate, are delicate instruments which may get out of adjustment. They are also costly and most of them require the measurement of distance in order to determine height.

The hypsometer shown in the drawing was designed to overcome many of the objections to standard hypsometers. It is based on long-known principles of proportion. Once the application of the stick is understood and the user acquires a little experience, it gives quick and surprisingly accurate results. Instructions for its use are given on the opposite page.

To estimate total height of tree.

(a) General (Recommended for trees 45'-100' in height). Select a position where the entire tree can be observed, preferably at a distance equal approximately to the height of the tree. Hold the stick lightly between the thumb and forefinger and let it hang by its own weight. Move it toward or away from the eye until the line of sight through the lower end of the stick cuts the base of the tree and that through the upper end cuts the tip of the tree. Quickly note the point at which the line of sight through the .1 graduation on the stick strikes the tree. Measure or estimate the height of this point above ground and multiply by 10 to obtain total height. If two men are available, as indicated in the diagram, one can slide his hand up and down the stem of the tree and thus help the instrument man in determining the .1 point, thereby insuring greater accuracy. The following are two examples of how to use the stick:

AC .10 AB; AC 5 feet; AB 50 feet
AD .56 AB; AB 50 feet; AD 28 feet

(b) Short Trees (Recommended for trees below 45' in height). Pass first line of sight through lower end of the stick and base of tree. Pass second line of sight through .1 graduation on stick and d.b.h. point on tree. Quickly note the point at which the tip of the tree cuts the stick. Read the graduation of the stick and multiply this value by 45 to determine total height of tree.

(c) Very Tall Trees (Recommended for trees over 100' in height). Select some distinct mark on the tree, such as a branch, a dry stub, or the base of crown. Pass the first line of sight through the lower end of the stick and the base of the tree. The second line of sight should pass through the upper end of the stick and the tip of the tree. Note the point at which the chosen mark (branch or stub) cuts the stick. Read the graduation and remember it. Next, estimate the height of the observed mark above ground as outlined in paragraphs A (a) and A (b). Divide the height thus obtained by the figure previously determined. This gives the total height of the tree.

B. To estimate number of 16-foot logs (stump height 2 feet).

(a) In order to determine the point where top of first, second, or third log comes on the tree stem, first pass line of sight through lower end of stick and base of tree. Pass second line of sight through the log-length mark -- for example, the two-log mark (Roman II) -- and then through the d.b.h. point on the tree. Move toward or away from the tree to accomplish this. The line of sight through the upper end of the stick will then cut the stem at the top of the second log. To determine top of first or third log follow the same procedure except use the log length mark for one log (I) or three logs (III).

(b) Another way may also be suggested. Place a mark on the tree trunk 5 feet and 1 inch above the ground. Move away from the tree until the first line of sight can be passed through the lower end of the stick and the base of tree, and the second line of sight through the .1 graduation, and the mark already made on the stem (5 feet and 1 inch above ground). Continue to hold the stick in position. The top of the first log will come at .36 on the stick, the top of the second log at .68, and the upper end of the stick will cut the top of the third log.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Jack Pine Normal Stand Tables

[illegible] normal yield tables usually give only total number of trees and [illegible]. To determine the available timber products in the stand, such as [illegible], ties, pulpwood, etc., it is necessary to know also the number of trees [illegible] diameter class. Such stand tables, based on [illegible] sample plots distri[illegible] throughout the three Lake States, are presented for jack pine. To use [illegible] one should know only the total number of trees and average diameter [illegible]. The average diameter is obtained by dividing the total basal area [illegible] number of trees in the stand. Thus, if the total number of trees per acre [illegible] the average diameter of the stand is 6 inches, then the number of [illegible] the 8-inch class will constitute 9.[illegible] per cent of the total number of [illegible] about 53 trees per acre, the number of trees in the 9-inch class 3.35 [illegible] or 19 trees per acre, etc.

[illegible]	Average Diameter of Stand - Inches									
[illegible]	2	3	4	5	6	7	8	9	10	Total
	Distribution of trees by diameter class in per cent of total number of trees									
[illegible]	26.20	8.00	2.58	.90	.44	.16	.07	.03	.01	
[illegible]	52.90	29.50	12.42	4.80	1.86	.76	.32	.13	.05	
[illegible]	18.50	37.90	27.50	13.40	5.80	2.18	.86	.27	.10	
[illegible]	2.35	18.60	29.90	24.30	13.40	6.85	2.68	1.27	.30	
[illegible]	.05	5.40	18.75	26.90	22.70	13.55	7.57	3.60	1.50	
[illegible]		.54	6.85	18.30	24.40	20.50	13.25	7.70	4.00	
[illegible]		.06	1.70	7.70	17.40	23.20	19.25	13.00	8.00	
[illegible]			.26	2.85	9.25	16.60	22.00	18.50	13.00	
[illegible]			.04	.70	3.35	9.30	16.30	20.50	17.44	
[illegible]				.14	1.05	4.78	10.30	16.00	19.80	
[illegible]				.01	.28	1.47	4.40	9.80	15.10	
[illegible]					.06	.43	2.10	5.40	10.40	
[illegible]					.01	.13	.66	2.40	5.80	
[illegible]						.04	.18	1.05	2.40	
[illegible]							.05	.26	1.45	
[illegible]							.01	.07	.45	
[illegible]								.02	.18	
[illegible]									.01	
[illegible]									.01	
[illegible]otal	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
[illegible]asis: [illegible]lots	1	20	34	54	60	49	26	8	2	254

[illegible]ber 1933.

* [illegible] by the United States Department of Agriculture, St. Paul, Minnesota, [illegible] operation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA
No. 72

Determining Volumes Without Volume Tables

The function of forest mathematics is not to evolve complicated formulas but to simplify field practice. On the strength of studies as to the relation between the form of the tree, the number of logs, and the diameter, it was possible to arrive at a simple accurate rule of thumb for determining the merchantable volume in Scribner log scale of trees, irrespective of species, without the aid of volume tables. The rule of thumb is this: Having ascertained the number of 16-foot merchantable logs and the diameter of the trees at breast height, (1) add 1 to the estimated number of 16-foot logs. Divide this sum by 4 and multiply the result by the square of the diameter; (2) add 1/2 to the number of logs and multiply this sum by the breast high diameter of the tree. The difference between these two calculations gives the content of the tree in board feet (Scribner rule).

Example: Sugar maple - 20 inches in diameter breast height. Number of logs - 3. First calculation: $\frac{3 + 1}{4} = 1$; $1 \times 400 = 400$.

Second calculation: $(3 + \frac{1}{2})\ 20 = 70$; $400 - 70 = 330$, which is the board-foot content of a tree of average form.

For one-log trees this rule of thumb should be modified. After the volume of the tree has been determined by the rule described, it should be further reduced by an amount 1-1/4 times the diameter.

Example: A tree 20 inches in diameter containing only 1 merchantable 16-foot log will scale by the rule of thumb 170 board feet. This should be reduced 1-1/4 x 20 or 25 feet, thus giving a net volume of 145 board feet.

For trees of smaller or greater taper than the average, a more accurate estimate can be obtained if, in addition to the number of logs and the diameter breast high, a third factor is taken into account, namely, the taper or form of the tree. The form of the tree is the ratio between the top diameter of the first 16-foot log inside bark and the diameter breast high outside bark expressed in percent. If, for instance, the diameter of the tree is 20 inches and the diameter inside bark at the top of the first log is 16 inches, the form is $\frac{16}{20} \times 100$ or 80 percent.

The form of the average tree is 75 percent. If a tree has a form of 80 percent, then the following correction should be made: Deduct from actual form of the tree (80) the average form (75), which gives 5. For every percent difference in form add 3 percent of volume or, in our example, 15 percent of 330 or 50 board feet. Should the tree be more tapering, say, 70 percent instead of 75, then 15 percent of the volume or 50 board feet should be deducted from 330.

The rule for the tree of the average form can be expressed as a formula:

$V = \frac{n + 1}{4} D^2 - (n + \frac{1}{2})D$, where V = Volume board feet Scribner, n = number of 16-foot logs, and D = diameter breast high.

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA
November 1933

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Stand and Yield Table for Jack Pine

Previous normal yield tables for jack pine in the Lake States gave [illegible] for the portion of the stand above only a single minimum diameter. The [illegible] presented here, however, gives yields for the stand above several lower [illegible] limits, thus making it possible to estimate the volume of various [illegible] products such as sawtimber, pulpwood, and ties. The yields are given [illegible] different age and site classes.

	Poor Site				Medium Site				Good Site			
	Age - Years				Age - Years				Age - Years			
[illegible]	20	40	60	80	20	40	60	80	20	40	60	80
Number of Trees Per Acre												
1" & larger	2940	1225	630	445	2000	850	440	310	1380	580	300	210
[illegible]" & larger	115	760	580	430	345	730	430	310	645	555	300	210
[illegible]" & larger	-	150	320	340	-	295	354	297	55	398	287	209
[illegible]" & larger	-	-	5	30	-	2	36	86	-	24	114	152
Total Cubic Volume per Acre 1/												
[illegible] larger	950	2250	2750	3000	1250	3100	3750	4100	1650	3950	4800	5250
[illegible] larger	235	1950	2700	2970	420	2950	3740	4100	1180	3920	4800	5250
6" & larger	-	650	2000	2700	-	1750	3470	4050	190	3430	4750	5240
[illegible]0" & larger	-	-	70	460	-	30	660	1860	-	420	2720	4470
Merchantable Cubic Volume per Acre 2/												
[illegible] larger	50	1350	2250	2600	250	2350	3350	3750	800	3400	4450	4850
6" & larger	-	500	1740	2400	-	1500	3150	3700	155	3030	4400	4840
[illegible]0" & larger	-	-	60	425	-	25	650	1760	-	390	2560	4160
Volume in Standard Cords per Acre 3/												
4" & larger	1	16	25	28	5	27	36	40	10	37	46	50
6" & larger	-	6	19	26	-	17	33	39	2	32	45	50
[illegible]0" & larger	-	-	1	4	-	-	6	13	-	4	26	42
Volume Board Feed Scribner per Acre 4/												
[illegible] & larger	-	100	2000	5000	-	1000	7500	12000	-	5500	15500	20000
[illegible] larger	-	-	200	1500	-	70	2200	6000	-	1400	10000	17600

1/ Includes bark, stump and top.
2/ Volume of wood with bark above a 1-foot stump and below a 3-inch cutting limit in the tops.
3/ Unpeeled cords to a top diameter of 3 inches outside bark.
4/ Trees 7 inches and over scaled to a top diameter of 6 inches inside bark.

[illegible]ay, 1934.

*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION[1/]
University Farm, St. Paul, Minnesota

How Much Solid Wood in a Cord?

Cords, cubic feet, and board feet are the most widely used units for expressing a quantity of wood. Converting factors of 6 board feet per cubic foot and 500 board feet per standard cord (8x4x4 feet) have been widely used. These factors are satisfactory when applied to large merchantable timber. However, they are not applicable to timber of small or medium size which is typical of present day conditions in the Lake States, where the bulk of the merchantable volume of forest stands is made up of trees averaging from 12 to 16 inches in diameter.

Measurements on 60 cords of paper birch bolts averaging in size 12½ inches and coming from trees averaging 12 to 16 inches in diameter were used in computing converting factors for trees of medium size. The stacks were all made up of unpeeled bolts. It was found that 1 cubic foot is equal to 5.3 board feet (Scribner) and an average cord contains: 421 board feet (Scribner), 92.1 cubic feet of wood with bark, or 79.6 cubic feet of wood without bark. For the determination of converting factors for still smaller trees 250 cords of spruce and balsam fir pulpwood were measured. Due to the greater amount of data secured, more detailed results were determined than for the birch studies.

The factors which should be used for trees of different diameters when converting cubic feet to cords are given in the table below:

White and Black Spruce and Balsam Fir
Converting Factors for Cordwood

Diameter Breast High of Trees	Middle Diameter Outside Bark of Bolts	Outside Bark	Inside Bark
		Per standard cord of 8-foot bolts Piled Unpeeled	
(Inches)	(Inches)	(Cu.ft.)	(Cu.ft.)
5	4.5	81.2	72.3
6	5.2	83.6	74.4
7	5.8	85.6	76.2
8	6.5	87.2	77.6
9	7.1	88.6	78.9
10	7.7	89.9	80.0
11	8.2	91.0	81.0
12	8.7	91.9	81.8
13	9.3	92.7	82.5
14	9.7	93.4	83.2
15	10.2	94.0	83.7

Standard Error of Estimate: 3 cubic feet per cord
Correlation Index (dbh and cubic volume per cord) - .57

These newly determined factors should be used in preference to the more common ones when the timber is of small or medium size and a good degree of accuracy is wanted.

May 1934

1/Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION[1]
University Farm, St. Paul, Minnesota

Estimating Fire Damage in the Lake States

Relative value per acre of second growth stands based on average merchantable value discounted to the average age of the size classes indicated.

Species	Average Size Class	Good	Medium	Poor
		Density		
		Value per Acre		
White or Norway Pine	0 - 4.5' high	$ 3.25*	$ 2.00*	$ .75*
	0 - 3" d.b.h	5.00*	2.75*	1.25*
	3 - 6" "	10.25*	5.75*	2.50*
	6 - 9" "	21.25*	12.00*	5.25*
Jack Pine	0 - 4.5' high	2.00*	1.00*	.50*
	0 - 3" d b.h	3.25*	1.75*	.75*
	3 - 6" "	8.75	5.00	2.25
	6 - 9" "	14.75	8.25	3.75
Aspen - Birch	0 - 4.5' high	1.00*	.50*	.25*
	0 - 3" d.b.h.	1.75*	1.00*	.50*
	3 - 6" "	6.00	3.25	1.50
	6 - 9" "	10.25	5.75	2.50
Oak	0 - 4.5' high	1.25*	.75*	.25*
	0 - 3" d.b.h.	2.00*	1.00*	.50*
	3 - 6" "	6.50	3.50	1.50
	6 - 9" "	10.00	5.75	2.50
2nd Growth Hardwoods	0 - 4.5' high	3.00*	1.75*	.75*
	0 - 3" d.b.h.	4.25*	2.50*	1.00*
	3 - 6" "	10.00	5.75	2.50
	6 - 9" "	14.50	8.00	3.50
White Spruce	0 - 4.5' high	3.00*	1.75*	.75*
	0 - 3" d.b.h.	7.75*	4.25*	2.00*
	3 - 6" "	21.50	12.00	5.50
	6 - 9" "	42.00	23.50	10.50
Swamp Timber	0 - 4.5' high	1.25*	.75*	.25*
	0 - 3" d.b.h.	2.75*	1.50*	.75*
	3 - 6" "	7.75*	4.25*	2.00*
	6 - 9" "	12.00	6.75	3.00

*Computed expectation value. Other values based on average yield of merchantable material.

May, 1934.

1/ Maintained by the United States Department of Agriculture, St. Paul, Minnesota in cooperation with the University of Minnesota.

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 76

Damage to Young Growth by Logging

One of the provisions of Article X of the Lumber Code is the protection of young growth in logging. It is, therefore, of interest to record the loss of seedlings and saplings during summer logging on the Superior National Forest, in a jack pine stand in which there was a mixture of black spruce.

The felling was done by CCC boys, many of them local woodsmen, under careful supervision. The skidding was done by experienced teamsters. In spite of all possible precaution, some 19 percent of the coniferous young growth (mostly spruce) between seedling size and saplings 1.5 inches in diameter, was destroyed in felling and skidding. If the logging had been done in winter some of the smaller, shallow-rooted seedlings at that time covered with snow might have been saved. On the other hand, summer logging, by stirring up the ground, encourages natural reproduction in this particular type where there is a thick layer of duff.

This information may serve as somewhat of a guide as to what may be expected in the way of loss in young growth even under careful logging in jack pine stands on the thin rock out-crop soils of northeastern Minnesota.

May 1934

LAKE STATES FOREST EXPERIMENT STATION 1/
University Farm, St. Paul, Minnesota

Damage to Advance Growth by Slash Disposal

Any method of slash disposal which involves burning inevitably results in more or less damage to advance growth. On the other hand, leaving slash unburned also destroys a certain amount of advance growth by burying and killing it or preventing it from developing normally. The following table shows the relative damage to advance growth resulting from various methods of slash disposal in an open all-aged stand of jack pine cut to a 6-inch diameter limit for fuel at the Michigan Forest Fire Experiment Station. 2/

Method of slash disposal followed	Percent of remaining stand			
	Undamaged	Injured	Killed	Killed and injured
Swamper burned...........	96	1	3	4
Piled and left unburned...	89	2	9	11
Piled and burned.........	74	8	18	26
Lopped and left unburned..	65	9	26	35
Undisposed...............	56	12	32	44
Broadcast burned.........	12	10	78	88

Damage to remaining trees is greatest where the slash is broadcast burned and next highest where it is left undisposed. It is considerable, however, in each of the other cases except where swamper burn (i.e. burned as cut) or piled and left unburned.

While the above figures cannot be taken as absolute, since the damage resulting from slash disposal necessarily depends on the abundance, size and distribution of advance growth present, they are of interest in showing the relative damage resulting from various methods of slash disposal under comparable conditions.

May 1934.

1/ Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

2/ Maintained at Roscommon, Michigan, in cooperation with the Michigan Department of Conservation.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Relative Hazard and Estimated Cost of Protection by Forest Types - Lake States

An analysis of Michigan forest fire reports for the years 1928 to 1932, inclusive, shows that, for the State as a whole, only 0.9 percent of the area burned was merchantable timber, while 47.3 percent was second growth, and 51.8 percent was non-timbered. Outstanding, however, is the preference of fires for aspen-birch second growth and grass plains, the former accounting for 25.2 percent and the latter 30.4 percent of the area burned. While this is largely due to the prevalence of these types, the figures in question serve to point out where the bulk of the protection problem lies.

Based on the best data available as to the area of the various types under protection, the percent of each type burned over annually, on the average, in Michigan, is as follows:

Merchantable Timber (all types, including saw-timber and cordwood stands)	0.04%	
Second Growth (all types)	0.64	
Oak and Oak-Hickory		1.00%
Pine		0.89
Aspen		0.73
Northern Hardwoods		0.50
Swamp Timber		0.28
Non-Timbered (all types)	1.74	
Swamp		2.68
Upland		1.59
All Types Combined	0.79	

These figures are of particular interest in that they show the "risk of burning" or relative hazard prevailing in each of the types in question. They may also be taken as indicating the effectiveness of present protective effort by types.

At present Michigan is spending on the average 3.5 cents per acre for protection. If we can assume that area burned varies inversely with the expenditu for protection, the relative cost of protection necessary to limit the area bur to one-half of one percent per year would be as follows:

Merchantable Timber	0.3¢ per acre	
Second Growth	4.5¢ " "	
Oak and Oak-Hickory		7.0¢ per acre
Pine		6.2¢ " "
Aspen		5.1¢ " "
Northern Hardwoods		3.5¢ " "
Swamp Timber		2.0¢ " "
Non-Timbered Land	12.2¢ per acre	
Swamp		18.7¢ " "
Upland		11.1¢ " "
Or for Michigan as a whole an average of	5.5¢ per acre	

On the basis of the above and the area of the various types involved, adequate protection (defined as protection sufficient to limit the area burned to half of one percent) would cost Wisconsin 5.1 cents per acre, Minnesota 5.6 cen per acre, or the Lake States as a whole 5.4 cents per acre.

May, 1934.

*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

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LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 79

Mortality in Selectively Cut Northern Hardwoods

Selective logging has been adopted by the Lumber Code Authority as a desirable woods practice in hardwoods. Although the advantages of this form of management are generally appreciated, some doubt has been expressed as to whether the mortality of the residual stand -- after selective cutting -- due to windfall and natural death of the trees, might not be so great as to make selective cutting entirely impracticable. Studies made by the Station, however, indicate this to be an entirely erroneous view.

Cutting experiments, varying from light selection to clear cutting, have been in progress at the Upper Peninsula Branch Station at Dukes, Michigan, since 1926. A 100 percent tally of mortality on these cutting areas, and on a virgin tract, has been made annually. Over 100 acres have been under observation for 5 years or more for the study of the single factor -- mortality.

The greatest percentage losses occurred in stands clear cut of all merchantable material and in virgin areas. On the clear-cut area, the annual loss was 1.5 percent of the volume in cubic feet. (There was no board-foot volume left after cutting.) In a stand from which 90 percent of the saw timber had been removed the loss was 21 board feet or 1.4 percent. The loss in the virgin area was 140 board feet per year.

On the other hand, in all true selective cuttings in which from 24 to 62 percent of the volume was removed, the average annual mortality was less than $\frac{1}{2}$ of 1 percent, or about 29 board feet, a totally insignificant figure. What makes this figure less important still is the fact that growth after deducting for all mortality was from 160 to 245 board feet per acre per year.

Of the total mortality in these selective cuttings, over half was due to trees being broken by the wind. About 1/3 of the trees lost were uprooted and less than 1/5 died standing.

Thus, it is very apparent that mortality after selective cutting is not a serious handicap, and that it is less in stands from which all defective material is removed by judicious selection, than in virgin stands or after clear cutting.

May 1934

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
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No. 80

Planting Under Aspen Can Be Made Successful

There are some 22 million acres of land covered with aspen in the Lake States. Much of this aspen will never reach merchantable size. Conversion of a large part of the aspen type to a more valuable forest by planting is an important silvicultural problem in the region.

The Station has demonstrated, after four years of experimentation, that plantations under aspen can succeed if the following measures are adopted:

(1) All undergrowth, such as hazel, sweet fern, etc., which competes with the planted trees, are repeatedly removed for several years after planting.

(2) The overstory of aspen is completely or entirely removed.

(3) Suckering of aspen is prevented by girdling the aspen overstory before cutting it down.

(4) The rabbit damage is eliminated.

The removal of the undergrowth is most important and the planted area should be kept free from it until the trees are above it. This treatment also materially reduces the damage from rabbits, as they usually congregate in brush-covered areas.

Where the overhead canopy of aspen is dense, at least partial removal of this overstory is necessary to insure the success of the planted trees. The growth of the plantation will be greater the more the upper story is removed.

To prevent aspen suckering as a result of removing the overstory, it is best to girdle the trees and let them stand a year or two before cutting them down. The girdling does not cause enough deterioration in the trees to prevent their utilization at the end of one or two years.

May 1934

LAKE STATES FOREST EXPERIMENT STATION[1/]
University Farm, St. Paul, Minnesota

Is Prairie Forest Planting Practical?

Since the early settlement of the prairies, settlers longed for a strip of woods to protect their homes from the blistering winds of summer and the cold blasts of winter. Forest planting in western North Dakota dates from about 1870. In spite of the stimulus of the Timber Culture Acts, only three-tenths of one percent of the total area ever was planted.

Within recent years complaints have become general that the old groves are dying out -- a situation which has a discouraging effect on new planting. The Experiment Station, therefore, undertook a study to determine the extent and causes of the decadence in these groves. It is hoped that if the causes of failure are thoroughly understood, changes may be suggested as to the kinds of trees and sites which are to be planted, and as to desirable treatments of the plantations which will assure their permanence and effectiveness.

The study revealed that in the planted groves, 15 to 40 years old, 30 percent of the trees are dead or dying. This high rate of loss has probably been the immediate result of drought starting in 1925 and continuing without much abatement up to 1934, with the exception of 1927 and 1928. Among other causes of death are: the general use of such trees as Carolina poplar, willow, box elder, and cottonwood, particularly on too dry sites; grazing of the groves by cattle and sheep; and general lack of care. The study further demonstrated that where the precipitation is not less than 16 to 18 inches, successful groves can be established providing the proper species and sites are chosen.

As a result of the study now completed, it is evident that Carolina poplar should be eliminated entirely, that willow should be used only sparingly on the moistest sites, and that box elder and cottonwood may still have a place in prairie plantings so long as they are kept off of the droughty soils of slopes and hilltops. Green ash is the most desirable hardwood for eastern North Dakota. Among the conifers, ponderosa (bull) pine, Scotch pine, Rocky Mountain red cedar (Juniperus scopulorum), and to a limited extent Colorado blue and Black Hills spruces, hold the greatest promise for prairie planting. With a proper selection of species and site, and good care, there is no reason why a planted grove should not last 65 years or more.

The study demonstrated further the value of shelterbelts in reducing wind velocity, and in this way protecting nearby fields against excessive drying-out in summer. Observations continued for a year near Towner, North Dakota, showed that the wind velocity, even at a distance of 300 feet on the leeward side of the shelterbelt, is only two-thirds of that in the open.

To secure the greatest benefit, narrow strips of trees should be planted around every quarter section. The small acreage thus far planted is no indication of what the climatic effect might be if the windbreaks were more extensive. It is estimated that at least 10 percent of the total land area would have to be planted before any noticeable climatic effect would be felt in the region as a whole.

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1/ Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Control of Rabbit Injury

Rabbits have caused a vast amount of damage to young conifer plantations throughout the Lake States. In many cases the number of trees severely injured or killed has been so high as to result in making the plantations as a whole failures. During the last few years, the rabbit population has been at or near one of its periodic peaks and this is undoubtedly a factor in the recent heavy losses in conifer plantations. The elimination of this damage is not a simple problem since certain aspects of game management must be considered as well as the production of forests. Three methods can be used for reducing the damage.

The first is to limit planting to more open areas during the time when the cycle of rabbit population is at one of its periodic high points as it is at present. It has been clearly demonstrated that rabbit damage is much greater in brushy areas than in more open sections and therefore the planting of lands densely covered with brush should be postponed until the decimation of the rabbit population occurs. Plantations made on such areas should then be released from brush before the rabbit population has again begun its upward trend. This protection should be given to the young trees until they have reached a height of at least three feet.

The second possibility is to reduce damage by controlling the number of rabbits, especially during the periods of high population. Several methods of control have been successfully worked out but no one of them alone is effective. The following are considered useful: snaring, poisoning, hunting, and live trapping. Attempts to make concerted drives on snowshoe hares have met with failure.

A third measure which gives promise of being helpful is to treat the seedlings before planting with sulphurized oil. This acts as a strong repellent to rabbits and has a possible added value in lessening the transpiration of the seedlings and thereby increasing their drought resistance during their first year in the field.

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*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

Technical Notes No. 83

LAKE STATES FOREST EXPERIMENT STATION[1]
University Farm, St. Paul, Minnesota

Use of Calcium Chloride in Forest Fire Control

Recent tests made at the Michigan Forest Fire Experiment Station[2] show that calcium chloride is an effective fire retardant and that, under certain conditions, it can be used to advantage in combating surface fires.

For example, when it was applied in water solution to a strip in advance of fires at the rate of one-fourth to one-half pound (dry weight) per square yard, it effectively stopped running fires in grass and sweet fern cover in every case except where the fire blew across the line or burned across in rotten wood or unusually heavy litter which the chemical solution failed to penetrate.

In regions of frequent precipitation calcium chloride is useful only as a temporary expedient since, owing to its ready solubility, even a light rain renders it ineffective. Calcium chloride is also ineffective when applied dry, since it falls to the ground and hence does not affect the inflammability of the fuels which carry the fire.

Satisfactory results depend on the complete and uniform treatment of the fuels on the strip to be fireproofed. This is best accomplished when calcium chloride is applied in solution with a sprinkler or pressure sprayer. The ordinary back pack fire pump is not satisfactory for this purpose, owing to its low and fluctuating rate of discharge.

While not likely to supplant ordinary methods of fire control, calcium chloride will be found useful in the establishment of emergency fire breaks and lines from which to backfire where man power is limited and plows are not available. Its usefulness, however, is confined to indirect attack, since it has no particular advantage over water when applied directly to burning material.

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1/Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

2/Maintained at Roscommon, Michigan, in cooperation with the Michigan Department of Conservation.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Is Jack Pine A Prolific Seeder?

Jack pine is commonly considered a prolific seeder, supplying sufficient seed each year to secure abundant reproduction. However, observations on the seeding of jack pine by the use of seed traps located both in uncut and in cut-over stands containing large numbers of seed trees, apparently upset this generally accepted view.

Because jack pine cones persist unopened upon the trees for many years, there is a tendency to overestimate the amount of seed produced each year. A 50 per cent cone crop is frequently reported for example, when careful examination shows that the actual crop of new cones is only about 10 per cent of full capacity.

Furthermore, the seed apparently continues to remain locked-up in unopened cones on the trees even after partial cutting. For example, during the summer and fall of 1933, a warm dry season, only one seed was found in nine seed traps (44 seeds per acre) in an 80-year-old cut-over stand on the Superior National Forest in Minnesota. Similar results were obtained in uncut stands on the Huron National Forest in Michigan (49 seeds per acre) and at the Michigan Forest Fire Experiment Station at Roscommon. Apparently the cones on jack pine seed trees cannot be depended upon to furnish sufficient seed for natural reproduction unless they are subjected to fire with its resultant injury to the parent trees.

On the other hand, cones in jack pine slash exposed to the heat of the sun in cut-over areas in northern Minnesota and Lower Michigan opened freely and scattered an abundant seed supply when the air temperature was 80 degrees F., and the surface temperature 120 degrees F. Tests on seed, from green, brown and old weathered cones, indicated satisfactory germination capacity, regardless of age.

Slash disposal by swamper (progressive) burning or by piling and burning soon after cutting destroys the greater part of this seed. If logging is done in the summer and the slash is not piled until fall, then some of the seed is dispersed, although the cost of slash disposal by delayed piling will be somewhat higher.

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*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION*

University Farm, St Paul, Minnesota

Forest Surveys an Aid to Sustained Yield Production

The lumber industry under Article X of the Code has committed itself to a sustained yield. The first step toward sustained yield management of forests is knowledge of the amount of timber by different sizes, loss through fire and cutting, and growth. As a concrete example, an area around Munising in the Upper Peninsula of Michigan may be cited.

The pulp mill at Munising consumes some 50 thousand cords annually and the sawmill and woodworking plant an additional 20 million board feet.

The area of forest land within the Munising unit is in the neighborhood of 450,000 acres. The amount of standing timber of saw-log size is close to 2-1/3 billion board feet in addition to 443,000 cords of hemlock, spruce and balsam pulpwood.

Because of the preponderance of old growth and recently clear-cut land, the present growth of hardwoods averages only about 67 board feet per acre or 20 million board feet in all -- just enough to meet the present requirements of the sawmill and woodworking plants in the unit. Under selective logging, this area should yield 160 board feet per acre, or 50 million board feet -- 2-1/2 times the present needs.

There are being grown in the swamps and in mixture with the hardwoods some 28,000 cords of pulpwood, spruce, balsam and hemlock, a little more than half of the requirements of the local pulp mill. However, since some of the hemlock sawtimber, as well as slabs, also can go into pulp, the requirements for wood pulp can also be nearly met by growth from the same area.

These facts indicate that the Munising area can be made self-sustaining and with proper treatment can even permit an enlargement of the sawmill industry. Without these facts, there is no basis upon which to plan self-sustained production.

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*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA No. 86

Ownership and Use of Land Determine Tax Delinquency

That tax delinquency is widespread throughout the cut-over region of the Lake States is a well known fact. But the underlying causes of this delinquency and the future trends are still a matter of speculation. Knowledge of the character of the land being abandoned and the importance of various factors in causing delinquency are essential if we are to understand the trends and suggest remedies for the situation.

For the purpose of obtaining such facts, four counties in the Upper Peninsula of Michigan have been intensively studied during the past year. The results of this study in some cases verify generalizations which have previously been made, in others lead to very different conclusions.

Delinquency varies with the type of land. Apparently, physical factors such as soil, topography, and cover are relatively the most important determinants.

Soils, it was found, had little effect upon tax delinquency of land held for timber or recreation purposes but on farms, as might be expected, the delinquency on soils classed as poor was double that on good soils.

Cover also apparently has a decided effect upon delinquency. Eighty-five percent of the total long-term delinquency in the four counties occurs on cut-over, marsh, or other wild land while only 15 percent is found on cultivated fields, pasture, timber or pulpwood areas.

The intent of ownership is a determining factor in letting land go for taxes. Long-term delinquency was found to range all the way from 0 to 31 percent, depending upon the intent of the owner in holding the land. Some of the figures were:

Intent of Owners	Tax Delinquency in percent
Private land listed under Timber Tax Law	0
Land held for power sites and other industrial uses	3.2
Land owned by operating farmers	4.0
Timberland owned by lumber companies	4.6
Land owned by mining companies	5.2
Summer resorts and other land held for recreational purposes	11.6
Land held for speculation	31.1

There are, of course, other factors influencing tax delinquency -- local tax rates, distance from market, even nationality and habits of the owner, which modify the above general trends.

May 1934.

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U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 87

How Effective is the Commercial Method of Treating Green Ash?

A common method used by nurserymen to increase the germination of green ash seed is to soak it in water at room temperature for 48 to 72 hours. The seeds increase in volume approximately a third, this seemingly being an indication of the efficiency of the treatment. However, while there is generally a correlation between the degree of swelling shown by a seed and its germination, this is not always the case. Since the large wings of green ash seed undoubtedly have a high capacity to absorb water, the increase in volume may be due to absorption of water by the wings rather than by the seed itself.

Tests conducted at this Station with seed of this species show that while water soaking increases the germination four times over that of untreated seeds, it by no means is as effective as stratification at low temperatures. The results of tests on a sample of seed from North Dakota are given in the following table:

Pre-Germination Treatment	Germination Percent	Days in Germination Room
None	3.4	65
Water-soaked - 48 hours	11.9	58
Stratified at 5°C. - 1 month	22.4	45
Stratified at 5°C. - 3 months	45.5	49

While soaking the seed increases germination almost fourfold, on the other hand, stratification at low temperatures is even more effective. The latter method not only gives from two to four times the germination obtained in commercial practice, but at the same time the period of germination is reduced by nine to thirteen days. Stratification of green ash seed therefore should be of considerable aid to those growing this species on a large scale.

August 1935

MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

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No. 88

Why Seeds Are Dormant

The rest or dormant period in plants has been defined as that period in which the plant or plant parts to all appearances do not grow. It is very common in seeds, bulbs, tubers, buds, and spores. In fact the majority of seeds will not germinate readily when placed under conditions which ordinarily result in germination.

Dormancy is caused by factors which inhibit the general processes preceding or accompanying growth. The dormant period is believed by some to be a direct response to changing environmental conditions and by others to be a result of heredity. In some seeds dormancy is probably due to a combination of both of these factors.

The causes of dormancy in seeds have been studied extensively and the following classes recognized:

1. Seed coat dormancy.
   a. Seed coat impermeable to water.
   b. Seed coat impermeable to oxygen.
   c. Hard seed coat preventing embryo expansion.

2. Embryo dormancy
   a. Embryo immature.
   b. Embryo needing "after-ripening."

The most common cause of dormancy in seeds is the possession of hard coats which are impermeable to water. This is especially true of the long-lived seeds, such as those of honey locust, Kentucky coffee tree, and most of the legumes. The number of species with seed coats impermeable to oxygen is relatively small. The seeds of cocklebur are dormant for this reason. The pigweed produces seeds with such hard coats that the expansion of the embryo is prevented.

Other species, including some of the members of the lily and crowfoot families have seeds whose embryos are still immature when the seed is apparently ripe. In these species the embryos mature while the seed lives in or on the ground, and the germination occurs several weeks or months later. Most of the rose family have seeds which must undergo certain internal changes before germination will occur. The physiology of this process which is called "after-ripening," is not yet fully understood.

There are, of course, seeds which have both dormant embryos and hard seed coats and still others with none of these characteristics.

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LAKE STATES FOREST EXPERIMENT STATION
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No. 89

How Can Seed Dormancy Be Determined?

In connection with the work on the Great Plains Shelterbelt project, seed samples of some forty odd species of trees and shrubs were sent in to the Station for germination tests. Many of these species had never before been used for forest planting, and in making the germination tests, it was found that the seeds of some of them would not germinate without pre-treatment. In order to determine what type of pre-treatment was best, it was necessary to find out whether the seeds were dormant, and if so, which of the two classes of dormancy they exhibited. In other words, was their dormancy due to seed coat or to embryo conditions?

The samples of seed were weighed and placed in petri dishes between layers of moistened filter paper. They were then put in an incubator, kept at room temperature (20 - 25° C.), and the absorption of water determined by weighing the seeds at three-day intervals for about two weeks. Seeds which readily absorbed moisture indicated that no treatment to overcome seed coat dormany was necessary, and that dormancy in this case was probably due to the embryo.

A test was then made to determine the condition of the embryo. The seed coat was removed under pressure and the naked seed placed in distilled water through which a stream of air was passed. If the embryo started to grow, it was assumed that no dormancy existed, and pre-treatment to overcome embryo dormancy was therefore unnecessary.

By means of these simple tests any kind of seed can be classified according to its type of dormancy. The probable dormancy classes thus determined for seeds of Shelterbelt trees and shrubs have already appeared in the "Forest Research Digest" for May 1935, a copy of which may be had on request.

August 1935

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No. 90

Some New Chemical Aids in Hastening Seed Germination

Seeds with embryo dormancy present problems which are not as easily solved as those of seed coat dormancy because of the many conditions which are associated with the rest period of the embryo. For several years it has been known that certain unsaturated hydrocarbons and their hydrin compounds stimulate the growth of parts of living plants and increase their life activities. Various organs of plants have thus been stimulated, including roots, stems, leaves, buds, flowers, and fruits.

As a part of tests made by the Station on the seed of trees and shrubs to be used in the Plains Shelterbelt Project, it was found that these chemicals can also be used to hasten germination of seeds which show embryo dormancy and have a relatively permeable seed coat. In the tests these compounds were used both in aqueous solution and as gases at ordinary temperatures and pressures. The results are as follows:

Aqueous Solutions - Ethylene-chloro-hydrin, ethylene-citro-hydrin, and glycero-phospho-hydrin, each used in 20-percent solution for 5 days, hastened the germination of smooth sumac seeds; ethylene-chloro-hydrin (10 percent for 5 days) that of Virginia creeper; propylene-citro-hydrin and glycero-phospho-hydrin (20 percent for 3 days) that of chittamwood.

Gases - The following gases and lengths of exposure were found to hasten the germination of chittamwood, hackberry, black walnut, smooth sumac, and soapberry: ethylene (5 and 10 days), butylene (5 and 10 days), amylene (5 and 10 days), ethylene-chloro-hydrin (5 and 10 days), propylene-chloro-hydrin (5 and 10 days), illuminating gas (10 days), acetylene (10 days), and ethyl-chloro-bromide (10 days).

On the basis of these results it is believed that the organic hydrins will be of great aid in solving the problems of seed dormancy and germination.

August 1935

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota.

Soils as a Guide in Forest Management

As a basis for selecting planting sites or determining species to use in onversion of aspen areas, the Station has correlated some of the 400 differ- oil types in the forested part of the Lake States with cover types. In studies it was found that differences between many of the soil types are eflected in differences of forest cover. The factor that controls the rrence of permanent forest cover is the water regime or moisture relation- p of the soil. Although soils may belong to several soil types, if they a similar water regime they will usually have the same forest cover. The ltypes were therefore classified on the basis of their moisture relationships six major groups. These six soil groups correspond to certain broad forest e as follows:

oil Group	Forest Cover	Characteristic Species
ry	Pine	Jack Pine and Norway pine.
'resh	Oak	White, black, and red oaks.
loist	Northern hardwoods of good quality	Sugar maple, beech, yellow birch, basswood.
Intermittently wet	Northern hardwoods of poor quality	Same species with yellow birch more important
Wet	Low land hardwoods	Elm, ash, soft maples.
Saturated	Coniferous swamp	Black spruce, cedar, tamarack.

The water regime of the soil is of course the resultant of many factors, as texture, depth of water table, character of the subsoil, and topography. se conditions can be easily recognized in the field, and the suitability of ven soil for forest purposes can therefore be readily determined. For sance, a sand with a subsoil of sand or rock, has a deep water table or none ll and is a dry soil. A sandy loam over a subsoil of clay, even with a ily low water table, is likely to be a fresh soil. A moist soil is the re- l of a combination of loam over sand or especially clay with a water table ot great depth from the surface. The remaining groups, intermittently wet, t and saturated soils, can be determined by their topographic position.

With these simple indications there should be no difficulty in determin- ng the moisture conditions of soils and their potential forest cover.

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*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 92

Growth Rate of Aspen Indicates Potential Forest Cover

As a result of clear-cutting, and fire, some twenty million acres of land in the Lake States are covered with aspen. Most of this aspen is of a temporary character and in the course of time will change to some other more permanent type. Since it is often impossible to find any evidences of the original forest, any scheme that will aid in determining the potential cover of these areas would therefore be of much value.

In connection with a detailed study made of the relation of forest cover and its growth to soils, it was found that there is considerable relationship between the potential cover types (as based on stumps, veteran trees, and other evidences of the original stand) and the rate of growth of aspen. Thus, aspen stands of high site quality (site index 70 and over) are generally produced on land formerly in hardwoods, either sugar maple, beech, yellow birch, and basswood or elm, ash, and soft maple. Land capable of producing white spruce and balsam will grow aspen of medium quality. Pine, oak, and coniferous swamp sites will support aspen with a generally poor rate of growth, often with a site index of less than 60.

Although the site index of aspen should not be used by itself to predict the potential cover of land now occupied by this species, it can be used as a supplement to the soil in making such a determination. For instance, if an aspen stand is found to be growing on a pine soil (such as a dry sand) and also has a low site index, the potential cover is almost certain to be pine. The soil, however, is a more reliable index than is the rate of growth.

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LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota.

Forest Areas in Minnesota

According to the Forest Survey of Minnesota recently completed by the Station, of the State's original forest area of 31½ million acres there now remains only 19½ million acres. Of the present area, 21 percent is unproductive having no actual tree growth but a cover of grass, bracken, alder, willow, hazel, or other brush. An additional 38 percent is occupied merely by aspen and scrub oak. Only 41 percent retains any semblance of the original types.

The great changes in the extent of the various forest types wrought by a century of logging, clearing and fires are shown in the following table:

Forest Type	Original Area Acres	Present Area Acres
Pine	5,800,000	1,670,200
Upland Spruce - Fir	6,300,000	1,088,300
Coniferous Swamp	6,100,000	3,330,400
Hardwoods	10,400,000	1,985,700
Aspen - Scrub Oak	2,900,000	11,540,800
TOTAL	31,500,000	19,615,400

A hundred years ago pine occupied around 5,800,000 acres of forest land; today it covers only 1,670,200 acres or but 29 percent of the original area. Only 19 percent of the original hardwood area remains and only 17 percent of that once occupied by white spruce and balsam. On the other hand, aspen, scrub oak, grass and brush have increased fourfold and now occupy over half of the forest area of the State.

The changes which have occurred in the size and quality of the timber are even more striking. The original forest contained at least 10 million acres of old growth pine, spruce and hardwoods. The present area of old growth sawtimber of all types is 343,000 acres or three percent of the original area. Two-thirds of the total present forest is below cordwood size, as indicated in the following table:

Size Classification of Present Forest

Old Growth Sawtimber	1.5%
Second Growth Sawtimber	6.2%
Cordwood	23.2%
Reproduction	47.8%
Deforested	21.0%
	100.0%

Thus the productivity of Minnesota's forests during the next 40 years will be closely tied up with the present limited areas of cordwood material. Yields will be largely in the form of pulpwood, ties, posts, mine timbers, rough lumber, and miscellaneous products.

A detailed progress report giving complete statistics on forest areas and cover types will be mailed upon request.

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*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in co-operation with the University of Minnesota.

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LAKE STATES FOREST EXPERIMENT STATION
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No. 94

Woods and Mill Cull in Merchantable Hardwoods

As a part of the Forest Survey it was necessary to obtain figures on woods and mill cull for application to the merchantable part of hardwood stands. Results given below of a preliminary study carried on in western upper Michigan are of considerable value in that they give a good indication of the amount of cull that must be deducted from gross volume estimates in that section. A more extensive investigation of cull is now being made and will be presented later.

These cull percents, based on some 500 trees, allow for high stumps, long butts, cull sections, sweep and mill cull, but do not include trees culled in the woods at the time of estimate. No definite figures have yet been obtained for the amount to be deducted in aspen, but it is believed these will run somewhere between 20 and 25 percent.

Species	Cull deduction Percent
Balsam	20
Basswood	25
Beech	30
Yellow birch	20
Elm	15
Hemlock	25
Sugar maple	20
Soft maple	30
Jack pine	5
Norway pine	5
White pine - virgin	15
White pine - second growth	5
Miscellaneous inferior hardwoods	20

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No. 95

Regional Variation in Composition of Old Growth Northern Hardwood Forests

The northern hardwood type is the characteristic forest cover of moist upland soils over the larger part of the three Lake States. Yet a closer comparison of the species that made up this type shows that there are very distinct regional variations in composition which make the old-growth hardwoods of western Upper Michigan distinct from the virgin hardwoods of northern Lower Michigan and from those of north central Minnesota. These variations, which are probably the result of climatic and soil differences, are illustrated in the accompanying table, based on over one thousand samples systematically distributed throughout the three areas in question. Although Wisconsin has not yet been covered by the Forest Survey, it is believed that the hardwoods of this state will most resemble those of western Upper Michigan.

Species	Western Upper Michigan	Northern Lower Michigan	North-Central Minnesota
	Percent of total number of trees		
Sugar maple	33.9	34.8	29.8
Basswood	2.1	8.3	37.6
Elm	0.9	13.4	3.1
Yellow birch	12.3	1.4	*
Hemlock	23.8	8.3	-
Beech	0.3	18.3	-
Oak	0.1	0.9	2.5
Aspen	0.2	1.2	3.6
Misc. conifers	16.4	0.4	11.7
Misc. hardwoods	10.0	13.0	11.7
All species	100.0	100.0	100.0

* Less than one-half of one percent.
Misc. conifers, spruce, balsam fir, pine.
Misc. hardwoods, ash, paper birch, soft maple, ironwood, cherry.

The species characteristic of all three regions is sugar maple which in no locality averages less than thirty percent of the trees. The most variable species are hemlock, beech, yellow birch, and basswood. On the basis of these figures it appears that the hardwood type in north central Minnesota is largely maple-basswood; in western Upper Michigan, maple-hemlock-yellow birch; and in northern Lower Michigan, maple-beech-elm.

Species which are not significant in characterizing the type are aspen, oak, paper birch, soft maple, and balsam fir. In the aggregate, however, these minor species make up from fifteen to twenty-five percent of the total stand.

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UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 96

Prolonged Exposure of Roots Causes Death of Planting Stock

Experiments conducted by this Station with the exposure of roots of 1-1 Norway pine, white pine, jack pine, and 2-0 white spruce to high temperatures and low humidities in a drought machine gave the following results:

Time of Exposure	Mean Temp. °C.	Mean Rel.Hum. Percent	Total No. Plants	Degree of Injury N.P.	W.P.	J.P.	W.S.
Minutes							
5	93.5	28.9	40	0	0	0	1
10	94.2	24.7	40	1	1	2	1
15	96.4	24.3	40	2	1	1	2
30	94.1	18.2	35	2	1	1	2
45	96.5	20.9	35	2	1	1	2
Hours							
1	95.8	16.3	40	2	2	1	2
2	95.8	17.4	36	3	2	1	2
5	95.4	19.1	35	3	3	3	4
6	99.4	18.1	20	4	4	3	4
7	97.6	20.5	20	4	4	3	4
8	98.0	17.4	60	4	4	4	4
9	100.2	19.8	20	4	4	4	4

0. No injury.
1. Slight injury to feeding roots.
2. Half of secondary roots and part of tap root dead.
3. All secondary roots and most of tap root dead.
4. Completely dead.

It is clear that even an exposure of over five minutes causes some injury to roots of all species while an exposure of more than fifteen minutes may prove fatal. The climatic conditions in the drought machine, however, are very severe and do not often occur in actual practice. Under field conditions the injury for different periods of exposure, although considerable should hence be somewhat less.

These tests indicate that the drying out of roots during planting and transplanting operations may be an important factor in causing subsequent losses. An effort should therefore be made to reduce exposure to a minimum.

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MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

What Trees Withstand Drought Best?

Results of forest planting during recent years show the desirability of knowledge of the drought hardiness of planting stock. Considerable light s thrown on this factor by experimental plantings made by the Station on he Huron National Forest in lower Michigan.

Plantations established in 1932 employing Norway pine, white pine, ack pine and Scotch pine of various classes showed excellent survival in idsummer of 1933. However, a very severe drought occurred in July and ugust of that year in the southern part of the Forest. In this area osses were enormous even in plantations ten years old and over. In the orthern part of the Forest rainfall was more abundant, although still ubnormal and the drought less severe. In the table below the survival, oth before and after the drought, is shown for typical areas in the southern Gordon Creek) and northern (Mack Lake) parts of the Forest.

These data show not only great differences in survival between the wo areas after the drought but also the better survival of transplant as ompared to seedling stock of several species. The survival percentages re based on analyses of approximately eight thousand trees for each area.

Species and Class of Stock	Survival Percentages: 1933 - Before Drought: Gordon Creek	1933 - Before Drought: Mack Lake	1934 - After Drought: Gordon Creek 1/	1934 - After Drought: Mack Lake 2/
Norway pine 1-0	85.4	83.8	3.4	62.1
" " 2-0	89.8	90.0	3.3	70.4
" " 1-1	95.4	97.5	6.4	83.2
" " 2-1	98.3	98.0	14.7	93.1
White pine 2-0	86.1	90.7	1.4	53.9
" " 1-1	93.4	96.4	0.0	71.4
" " 2-1	97.4	98.3	8.6	77.2
Jack pine 2-0	56.4	54.1	14.2	50.1
Scotch pine 2-0	85.9	76.6	13.4	71.0
" " 2-1	99.4	99.1	35.4	97.5

1/ Subjected to severe drought.
2/ Subjected to slight drought.

It might be pointed out here that the results with jack pine are not onsidered representative of this species. The low initial survival was due argely to abnormally high winter losses of poorly "hardened" stock which ad been much too thick in the seed bed.

ugust, 1935.

*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION 1/
University Farm, St. Paul 1, Minnesota

What Rainfall Factor Causes Drought Damage?

The chief factor causing droughts is usually considered to be low precipitation over a comparatively long period. However, within reasonable limits the distribution of rainfall over a period of several months may be of even greater importance than the total amount. This is quite clearly brought out by experimental plantings on the Huron National Forest, in which a rather striking contrast is shown between the results of 1933 and those of 1934 presumably due to different distribution of rainfall during these two growing seasons.

Although the year 1933 is considered as probably the worst drought year on record on the Huron National Forest, the rainfall on the various plots during the growing season averaged from 1.83 inches to 3.23 inches greater than in 1934. As may be seen in the table, however, first year survivals were uniformly better in 1934 than in 1933.

In 1933 there was an unusually wet spring followed by a warm, early summer. As a result the trees produced long succulent shoots and had no chance to develop resistance to the coming arid conditions. Then the rain abruptly ceased and on the Tawas District, including the Gordon Creek and Sand Lake Blocks, the lowest combined July-August precipitation on record resulted. On the White Pine block a good shower broke the July drought; on the Mack Lake area occasional showers reduced the deleterious effects of both July and August conditions. Accompanying the low precipitation were abnormally high temperatures. The enormous losses on the Gordon Creek and Sand Lake Blocks, and the better survivals on the other blocks reflect these climatic conditions quite accurately.

The spring of 1934 was drier than normal, and consequently, the trees produced short shoots only. Although maximum temperatures even higher than those of 1933 were recorded and the total rainfall was less, first year survivals were **uniformly** fair to excellent in 1934. The answer evidently is better rainfall distribution for no monthly totals were as low in 1934 as in 1933. The rainfall was hence sufficient for a majority of the trees to make slight growth without exhausting the reserves of moisture in the upper soil layers.

Block and Plot	Norway Pine				White Pine			Jack Pine	Scotch Pine		Rainfall May through Mid-Nov.
	1-0	2-0	1-1	2-1	2-0	1-1	2-1	2-0	2-0	2-1	(Inches)
1933	Survival percent - end of first year										
Gordon Creek (8)	3	3	6	15	5	0	9	14	13	36	13.47
Sand Lake (19)	4	9	10	28	6	11	17	23	22	49	13.92
White Pine (22)	18	38	48	59	46	55	54	21	31	76	15.06
Mack Lake (32)	53	70	83	93	54	71	77	50	72	97	15.79
1934											
Gordon Lake (9)	71	84	86	91	75	80	89	61	84	98	11.64
Sand Lake (18)	47	75	76	92	73	66	86	36	64	91	11.87
White Pine (23)	47	58	48	83	48	59	67	34	66	86	11.83
Mack Lake (33)	74	98	86	96	74	89	90	51	70	98	13.08

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1/ Maintained by the United States Department of Agriculture, St. Paul, Minnesota in cooperation with the University of Minnesota.

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No. 99

Seedlings or Transplants

A planting test established by the Station in the fall of 1931 upon the Huron National Forest already shows some very striking differences in the growth and survival of seedling and transplant Norway pines. It is noted that at the end of the third year, one of which was accompanied by a severe and another a moderate drought, the survival percentages in all cases were better for 2-1 stock than 2-0. In all but one case the height growth of the transplant stock was also superior. These points are illustrated in the following table.

Block	Class of Stock			
	2-1		2-0	
	Survival	Ht. Growth	Survival	Ht. Growth
	Percent	Inches	Percent	Inches
Sand Lake	60.0	2.7	22.7	2.0
Gordon Creek	71.0	5.5	48.3	3.1
White Pine	46.3	4.8	39.0	4.9
Mack Lake	97.7	6.5	74.3	3.4

Upon analysis these results indicate that, looking at the matter purely from the standpoint of cost of establishment and disregarding other factors, such as loss of time and growth, it is more economical to plant 2-1 than the cheaper 2-0 Norway pine on the poorer pine sites found in the lower Michigan sand plains. On better sites it would prove more economical to plant 2-0 Norway pine more densely to obtain the same stocking as would result from the use of 2-1 trees at the present density of planting.

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No. 100

Effect of Shade in Reducing Soil Surface Temperatures

The shade cast even by small shrubs and herbaceous plants frequently cools the surface of the soil sufficiently to be an important factor in the survival of planting stock.

Records obtained on the Huron National Forest of maximum soil surface temperatures indicate that such temperatures under partial shade during the summer period are frequently as much as 18 to 30 degrees less than in the open. This difference was sufficient in all cases to bring the temperatures below the point ordinarily severe enough to cause the death of young trees. The data are given in the table below:

Block	Ave. maximum air temperature in instrument shelter Degrees F.	Ave. maximum temp. soil surface Degrees F. Open	Part shade*	Difference Degrees F.
Sand Lake	82.0	126.5	94.2	32.3
Gordon Creek	81.1	124.6	107.0	17.6
White Pine	81.0	119.0	91.5	27.5
Mack Lake	80.0	124.5	94.7	29.8

* Taken at ½ tree height to north of shading plant.

A second set of observations shows the same trend in another manner. Soil temperatures at one-inch depth taken at noon at various distances to the north from the shading plant become progressively lower as the source of shade is approached, as follows:

Average noon temperature at one-inch depth, degrees Fahrenheit

Month	Open	3/4 tree height	1/2 tree height	1/4 tree height
June	79.5	79.5	73.5	67.8
July	86.7	84.8	79.0	70.8
August	75.7	73.8	67.7	62.8

Measurements made at several points show the same general relationship, but, as might be expected, the absolute values vary with the density of shade and the kind of soil.

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LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St Paul, Minnesota

Soil Treatment Greatly Increases Jack Pine Reproduction

Although considerable literature has been published on how to secure jack pine reproduction, relatively few cases are known where investigators have actually obtained reproduction in any quantity by use of the recommended methods. The experiment described below explains a method by which a significant number of jack pine seedlings were obtained as a result of the treatment of the stand and soil.

The experiment was carried out in a stand of 70-year-old jack pine growing on shallow loam soil in the rock out-crop region of northeastern Minnesota. Other species represented in the stand were black spruce, paper birch, and aspen.

In October 1934, the following soil treatments were used: (1) all duff removed with mattocks and rakes, and (2) duff torn up or "disturbed" with mattocks On another area the duff was left undisturbed. During February 1935 the area was cut clean and the slash carefully lopped and scattered. By early summer it had dried out sufficiently to permit some of the seed to fall from the jack pine cones. Due to unusually favorable moisture conditions, germination commenced about the first of July. Reproduction counts made in early August showed the results given in the following table:

Number of Seedlings Per Acre

Soil Treatment	Species		
	Jack Pine	Black Spruce	Paper Birch
Duff not disturbed	0	0	333
Duff disturbed	1,365	45	728
Duff removed	14,250	1,425	4,950

Removal of the duff, which in this case was tough and about 2 inches thick, greatly stimulated reproduction. Proper mechanical equipment has yet to be developed to make these results of practical use on rough rocky sites. On sandy areas, however, many implements such as disk and spring-tooth harrows or plows of various kinds could be used to advantage in exposing the mineral soil.

January, 1936

*Maintained by the United States Department of Agriculture at St. Paul, Minnesota in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

The Protective Influence of the Forest

Statistical studies show that well-timbered forests in the Lake States are relatively safe from fire. Once the timber is clean cut, however, and the land exposed to the sun and wind, fire hazard increases tremenduously.

The northern hardwood-hemlock forest furnishes an excellent illustration. This type when in a virgin condition is as nearly fire proof as any type of forest in the region, but the removal of the protecting influence of the old forest immediately changes the situation and allows the elements to have full play.

How greatly the overhead shade reduces the wind and temperature (the two factors chiefly responsible for drying the forest) are shown by the results of 5 years of detailed weather records taken at the Upper Peninsula Experimental Forest near Marquette, Michigan. Records were taken both in the open and in the virgin forest.

Average Soil Temperature at One Inch Depth in Degrees F.

Station	May	June	July	August	Sept.
Open	52.1	62.4	69.5	66.7	57.4
Forest	48.6	55.2	60.2	59.0	55.2

The reduction of soil temperatures caused by the forest cover although important is not as striking as the effect on wind movement. During the summer period the wind is nearly three times as strong in the open as in the forest, as shown in the following table:

Average Daily Wind Movement in Miles at Fifteen Foot Level

Station	May	June	July	August	Sept.	Oct.
Open	96.2	79.6	63.2	59.2	65.3	89.3
Forest	51.6	25.6	14.5	16.4	17.3	37.4

January, 1936

*Maintained by the United States Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION 1/
University Farm, St. Paul 1, Minnesota

Planting Stock Must Contend with High Surface Temperatures

Experimental findings have pointed out that small trees, such as the seedling stock commonly planted in the field, may be killed by exposure to temperatures of approximately 125° F. That soil surface temperatures frequently exceed this amount is indicated by measurements carried out in connection with a comprehensive planting experiment on the Huron National Forest.

During the period August 17-28, 1933, the average maximum temperature at the surface in one planting block was 155.2° F. During this time all maxima were over 150° and the highest reading was 162° F.

Again, for a 17-day period in June 1934, the average maximum temperature of the surface soil at the same location was 143° F., with all readings over 130°. Even later in the season, from August 28 to September 7, 1934, the average maximum temperature at the soil surface was 110.2°, the lowest record being 83° and all others over 100°.

It is thus evident that small trees in plantations are frequently subjected to potential lethal temperatures, and even though these exposures are often of short duration, the repetition of such conditions weakens the trees and eventually causes the death of those least hardy.

January 1935

1/ Maintained by the United States Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St Paul Minnesota

Does Stock Balance Affect Survival?

Although well balanced stock is commonly recognized as one of the necessities for successful planting, little information is available in this region as to what top-root ratios are best for the species and classes of stock commonly planted. The following data should, therefore, be of interest as shedding some light on the problem.

Two groups of Norway pine seedlings were established in the nursery at East Tawas, Michigan, at the same time. Group A was sown in an average seed bed near the center of the nursery and Group B in an outside seed bed adjacent to a white cedar hedge. At the end of the first year half of each group was transplanted to adjacent inside beds so as to produce 1-1 stock while the other half was left in the original seed beds to produce 2-0 stock. After two years in the nursery both groups of stock were field-planted at several localities under identical conditions. The table below gives the essential data for each group and class of stock.

Factor	2-0 Norway Pine A	2-0 Norway Pine B	1-1 Norway Pine A	1-1 Norway Pine B
Shoot lengths-inches	2.39	2.29	1.59	1.56
Root " "	8.05	6.24	9.56	9.72
Shoot weight-grams	2.68	2.00	1.69	1.68
Root " "	0.70	0.49	1.08	0.94
Top-root ratio	3.8	4.1	1.6	1.8
Ave. Survival percent	76.8	68.6	82.8	73.2

First year survival values are consistently higher for the trees with the lower top-root ratios (Group A) in both classes of stock. It is also shown that the transplant stock of each group has better balance and also higher survival than the corresponding seedling stock.

January, 1926

*Maintained by the United States Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 105

Natural Reproduction is Affected by Weather Conditions

Carefully planned silvicultural operations sometimes fail because of the weather as brought out by recent experiments with jack pine at the Superior Branch.

During 1933 and 1934 (dry years) jack pine cones contained in slash opened readily during the summer even under partial shade. During this period reproduction succeeded best where protected by some overhead cover.

In 1935 behavior of cuttings was entirely different. On a clear-cut plot cones opened slowly during the spring and early summer while on a partial cutting where 50 percent of the stand was left they opened scarcely at all. Such seed as escaped germinated quickly during July and August, whereas in 1934 no germination occurred during the middle of the summer. By the end of August there were 16,375 seedlings per acre on the area clear-cut in 1935, but only 1,320 seedlings on the partial cutting.

The explanation of these differences lies in the weather of the different years. Much greater precipitation occurred during the summer of 1935 than in the two previous years as is shown by the following table:

Year	Rainfall in inches			
	June	July	August	Total
1933	4.82	2.86	2.10	9.78
1934	2.77	1.86	1.94	6.57
1935	4.20	6.47	3.81	14.48

In 1935 on the clear-cut area short periods of dry weather were sufficient to dry out cones and cause some seed dispersal. With partial shade, however, there was little opportunity for the cones to dry between rains. The humid weather of 1935 was also favorable for the growth of damping-off organisms. These fungi caused high mortality among young seedlings throughout the season, especially among those growing in the partial cutting.

January 1936

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota.

Abrasives Used in Scarifying Forest Tree Seeds

Scarification of hard coated seeds, to hasten germination, has been a common practice for many years. Up to now, however, most of this work has been done by farmers with seeds of clover, lespedeza and other legumes. For this purpose, either the "Barrel" or "Ames" scarifiers are satisfactory. In the "Barrel Scarifier" stream bottom gravel is used as an abrasive, and in the "Ames" machine the seeds are blown against emery cloth or paper for a very short period of time. It has been reported also that hard coated seeds of legumes, lettuce, mustard, okra, and snapdragon can be made to germinate more quickly by being blown against needle points.

Forest tree seeds, such as those of juniper and hawthorn, need a much severer treatment, however. In connection with its seed studies, the Station has developed a revolving drum scarifier (9 inches wide by 3 feet in diameter) operating at a speed of about 40 to 45 R.P.M. The efficiency of the following abrasives was tested:

1. Crushed quartz of two grades, fine and coarse. Four tin baffles were spaced at regular intervals around the inside of the drum. The volume of quartz to seed was 2 to 1.

2. Number 12 aluminum oxide grit. The baffles were also used in this test. The ratio of abrasive to seed was the same as above.

3. Six silicon carbide blocks (9 inches by 2 inches by 1 inch) were substituted for the baffles.

4. The drum was lined with No. 2-1/2, grade 30 E, garnet paper.

5. The drum was lined with No. 2-1/2, grade 30 E, silicon carbide paper.

The only abrasive which proved to be of practical value was the silicon carbide paper. In the machine described above, satisfactory scarification of two pounds of juniper seeds was obtained in three days.

At the Station's North Dakota branch a larger, but otherwise similar machine (2 feet wide and three feet in diameter with a speed of 20 to 30 R.P.M.) has demonstrated that scarification of forest tree seeds can be done on a commercial scale. The Denbigh scarifier with certain refinements will satisfactorily scarify 20 pounds of juniper seed in two to four days.

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*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota

Scaling Cull in Standing Trees in Board Feet, Scribner Rule

Board foot volume tables show only the gross content of standing trees of various dimensions. In order to obtain the net woods scale, the gross volume must be reduced by the amount of defect present in the trees. Frequently the deduction for such defective portions in standing trees is made without regard to the scaling practice used in the construction of the volume tables which are applied. Even when the trees are down and cut up into logs, it is not proper to scale the defective portions on the basis of their top diameters and subtract the volumes from the gross scale as given by the volume table.

If the estimator is able to judge the lengths of the defective portions in standing trees, then in reducing the gross scale of a tree as given by a volume table to the net scale, he may use the following formulae. These give volumes of defective portions in board feet Scribner Rule (v) when the tree diameter outside bark at breast high (D) in inches, and the length of the defective portion (L) in feet are known. Diameter is expressed in inches and length in feet.

1) $v = \frac{D}{10} \left(\frac{3D}{10} - 1\right) L$ when defective portion is below the top of 1st 16-foot log

2) $v = \frac{D}{10} \left(\frac{2\frac{1}{2}D}{10} - 1\right) L$ when defective portion is below the top of 2nd 16-foot log.

3) $v = \frac{D}{10} \left(\frac{1\text{-}2/3D}{10} - 1\right) L$ when defective portion is below the top of 3rd 16-foot log.

Example: A tree, 20 inches in d.b.h. has a defective butt, extending 5 feet above the stump. How many board feet should be subtracted from the volume table scale for that tree?

Answer: Using formula 1) we get $v = \frac{20}{10} \left(\frac{60}{10} - 1\right) 5 = 2(6-1)5 =$ 50 board feet.

Example: Half of the second log of the same tree is defective. What is its board foot scale?

Answer: Using formula 2) we get $v = \frac{20}{10} \left(\frac{50}{10} - 1\right) 3 =$ 64 board feet.

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TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 109

Woody Food Preferences of the Snowshoe Rabbit in the Lake States

The kinds of woody plants eaten by the snowshoe rabbit in any one locality are quite largely determined by the species present and their relative abundance. There are, however, a few plants distributed throughout practically the complete range of these animals which make up a large part of their diet. Among the deciduous species young aspen, willows, and the birches are probably the preferred foods. Others are readily eaten but to a much lesser degree. These include hazel, alder, dogwood, red oak, silver maple, wild rose, cherry, raspberry, and sumac.

In the coniferous group, the rabbits show a decided preference for jack pine, white pine, and tamarack. Other evergreens less frequently eaten, but commonly damaged when other food is scarce, include Norway pine, white spruce, Scotch pine, and white-cedar. Black spruce and balsam fir are much less often utilized.

Seldom do the animals cut off stems or twigs which are more than a half inch in diameter. Usually, however, they nip off the buds or the tender portions of the twigs such as the branch tips or gnaw the bark. The amount eaten of the portion cut off varies anywhere from zero to one hundred percent. Woody plants are used as food mainly during winter but considerable amounts are also consumed during the spring and fall months. In summer this diet is largely replaced by a more succulent menu of the tender grasses and herbs.

It is thus evident that as far as damage from rabbits is concerned, the critical period for coniferous plantations is the fall and winter months. Any scheme for control of depredations by these animals should, therefore, take this fact into consideration.

January 1936

LAKE STATES FOREST EXPERIMENT STATION*
University Farm, St. Paul, Minnesota.

Fuelwood More Valuable than Lumber in Minnesota

Fifty percent more fuelwood was produced from farm woodlots in 1934 han was reported by the United States Census of Agriculture for the year 929 In the earlier year 1,163,000 cords of wood were reported cut for farm se or for sale, an average of 6 3 cords per farm, while in 1934, according o a brief field check conducted by the Forest Survey, production was estimated o be 1,744,000 cords, or 9.3 cords per farm.

Although the total amount of fuelwood cut was greater the actual de letion of merchantable timber was less than commonly supposed Survey figures ndicate that practically two thirds of the wood cut for fuel came from trees nmerchantable for lumber or other commercial products Percentages ran as ollows:

Cut from cull or dead trees	60 percent
Cut from logging and mill waste	5 percent
Cut from trees suitable for low-grade lumber	10 percent
Cut from sound 6 inch and 8 inch trees	25 percent

Of the volume cut on farms in 1934, 27 percent was aspen and cottonwood, 9 percent oak, 14 percent tamarack, 10 percent elm, and 3 percent pine The emaining 27 percent was made up of miscellaneous hardwoods, mainly birch, aple, ash and basswood.

Fuelwood values vary with locality and with species Common prices n the north are from $2 50 to $4 00 per cord of 128 cubic feet. In the outhern counties where wood is more scarce and hauling distances are greater, ak and other heavy woods commonly sell at $6 00 to $7 00 per cord At an verage value of $5.00, the 1,744,000 cords of wood cut in Minnesota last ear would have a total value of $8,720,000, which is twice the value of the umber produced in the same year.

The great increase in fuelwood consumption during recent years can be ttributed largely to the lack of ready cash on the farms Farmers have not nly been burning wood in place of coal and oil, but many have paid their ills by delivering fuelwood to merchants, schools, and court houses. This s undoubtedly but a temporary situation in southern Minnesota where both ncreasing scarcity of wood and improved facilities for distributing oil, ork toward the replacement of the former as an important source of heat n the north, however, there seems to be no reason why wood should not con inue to be the most satisfactory fuel for rural consumption.

'anuary, 1936.

*Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL MINNESOTA

Millions of Posts Needed to Repair Minnesota Fences

About 470,000 miles of fences are in use on the 185,000 Minnesota farms, or an average of about two and a half miles per farm. Construction of these fences necessitated the use of nearly 150 million fence posts. Annual maintenance requires the cutting and placing of about 11 million posts each year. These facts concerning one of the important local forest products in Minnesota were obtained in connection with the Forest Survey conducted by the Lake States Forest Experiment Station in 1934.

Only 5 per cent of the posts now used in Minnesota are made of steel or cement; 95 per cent are wooden posts.

The kinds of wood involved in normal annual replacements are approximately:

Oak	6,380,000	posts	58	per cent
Aspen	1,430,000	"	13	"
Cedar	1,210,000	"	11	"
Tamarack	660,000	"	6	"
Pine	440,000	"	4	"
Balsam	330,000	"	3	"
Misc. Hardwoods	550,000	"	5	"
	11,000,000	posts	100	per cent

Less than half of the posts cut each year in Minnesota are taken from trees which would be merchantable for lumber, ties, poles or other valuable products. One-sixth are cut from dead or cull trees; another 15 per cent from tops, limbs or other unused parts of merchantable trees after the poles or ties have been removed. Nearly one-quarter are cut from small trees below 5 inches diameter. Only 44 per cent come from sound merchantable trees.

To supply 11 million fence posts, the equivalent of nearly 230,000 cords of wood must be cut each year. This is about one-third of the volume of wood cut for lumber in recent years, but of course is much smaller and poorer material than that used by sawmills.

Farm fences throughout the State are in a poor state of repair. During the depression replacements have not been made except where absolutely necessary. Short-lived inferior woods have been used in many recently constructed fences because they could be obtained without cost. With improving farm conditions, there will doubtless be extensive renewal of broken-down fences and annual requirements may considerably exceed the normal 11 million for a number of years.

No. 111 May, 1936

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Volume of Plantation Cottonwood, Board Feet - Scribner

The accompanying volume table, based on measurements obtained by the tation in McHenry County, North Dakota, shows the average board-foot cont of planted cottonwood trees.

These trees are characterized by a pronounced butt-swell and very hick bark, especially in the lower third of the tree. The double-bark hickness at breast height comprises 16-1/2 per cent of the outside diameter.

IcHenry County
Iorth Dakota 1935

Diameter Breast High Inches	Number of 8-foot logs 1	2	3	4	5	6	7	Basis Trees
	Volume - Board Feet							
10	12	18	24	28	32			22
11		24	32	39	46	51	56	21
12		30	42	52	60	67	74	7
13			52	66	76	87	96	4
14			63	80	95	108	121	4
15			76	96	114	130	149	-
16			90	113	135	156	182	2
17				132	158	185	212	2
18				152	180	215	245	
19					205	246	278	
20					230	276	315	
Basis			2	23	16	15	6	62

Volume includes stem without bark above a one-foot stump to a top diameter of six inches, inside bark.

Scaled by Scribner rule, using 8.15-foot sections. Blocks indicate the range of field data.

No. 112

May, 1936

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 113

Peeled Volume of Plantation Cottonwood - Cubic Feet

Measurements obtained by the Station in McHenry County, North Dakota, form the basis for the accompanying table which gives the average total volume in cubic feet for plantation cottonwood.

These trees are characterized by a pronounced butt-swell and very thick bark, especially in the lower third of the tree. The double-bark thickness at breast height comprises 16-1/2 percent of the outside diameter.

McHenry County, North Dakota — 1935

Diameter breast high	Total height - Feet 30	40	50	60	70	80	90	Basis
Inches	Volume - Cubic Feet							Trees
4	1.01	1.17	1.38	1.61				4
5	1.55	1.75	2.07	2.45				4
6	2.24	2.63	3.16	3.64	4.10			5
7	3.10	3.65	4.25	5.00	5.65			13
8	4.02	4.71	5.59	6.46	7.39	8.26	9.20	18
9	5.03	6.08	7.10	8.20	9.30	10.40	11.00	20
10	6.25	7.50	8.78	10.13	11.48	12.90	14.30	22
11	7.45	9.00	10.60	12.20	13.75	15.55	17.05	21
12	8.85	10.50	12.50	14.47	16.45	18.40	20.35	7
13		12.40	14.70	16.95	19.30	21.50	23.90	4
14		14.38	17.05	19.75	22.48	25.10	27.80	4
15		16.45	19.55	22.75	25.85	28.90	32.00	-
16		18.65	22.00	25.80	29.40	33.00	36.50	2
17			24.95	29.05	33.30	37.40	41.65	2
18			28.20	32.65	37.48	42.15	47.00	-
19				36.35	41.80	47.10	52.45	-
20				40.40	46.30	52.30	58.20	-
Basis	5	15	36	36	25	8	1	126

Volume includes stump, stem, and top, all without bark. Blocks indicate the range of field data.

May 1936

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

LAKE STATES FOREST EXPERIMENT STATION 1/
University Farm, St. Paul 1, Minnesota

Conversion of Tree Volumes from Scribner to International ¼" Rule

oth Scribner and International (¼") log rules are widely used in scaling saw imber throughout the United States. Tree volumes in board feet can be converted rom one scale into another without re-scaling individual logs, provided, of ourse, that the same minimum top diameter is used.

he conversion factor depends upon diameter breast height, merchantable height, nd tree form. The latter is the ratio between the top diameter inside bark of he butt-log and the diameter at breast height. Based upon the analysis of nine undred and fifty trees of different species, the following table has been developed in which the effect of each of the three factors is expressed by a ertain multiplier and the net result, or the required converting factor, as a roduct of the three corresponding multipliers.

DBH (inches)	Multiplier	Merch. Height No. of 16-ft. logs	Multiplier	Form class °	Multiplier
10	1.332	1	.985	.70	1.015
12	1.248	2	.993	.75	1.005
15	1.165	3	.999	.78	1.000
20	1.104	4	1.003	.80	.996
25	1.079	5	1.006	.85	.986
30	1.066	6	1.008	.87	.983

°Ratio between top DBH of butt-log and DBH

he required conversion factor for any specified tree is the product of the three corresponding multipliers tabulated above.

XAMPLE: A tree 20 inches DBH contains two logs, one 15 inches and another 13 inches at the small end, scaling together 246 board feet Scribner. What is the volume by International 1/4" rule? The form class here is $\frac{15}{20}$ = .75. The product of the three multipliers is 1.097, i.e., 1.104 x .993 x 1.005 = 1.097, and the required volume 1.097 x 246 = 271 board feet. Since the size of the logs is known, this volume can be checked. The International scale for a 15-inch log is 157 board feet and for a 13-inch log 114, or a total of 271 board feet. Due to the fact that the size of logs in standing trees is rarely known, this conversion table is of considerable practical value.

If the exact form class is unknown, its corresponding multiplier can be omitted since the average form class of the Lake States timber is .78 for which the multiplier is equal to 1.

May 1936

1/ Maintained by the United States Department of Agriculture, in cooperation with the University of Minnesota.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Nursery Shade Requirements of Ponderosa Pine

In nurseries producing coniferous stock, the seed beds are often shaded ing the first year to protect the young seedlings from high surface temper- res. This practice increases by a considerable amount the cost of producing n stock.

Experiments recently conducted by the Station in the new Forest Service sery at Towner, North Dakota indicate, however, that seedlings at least of derosa pine can successfully be grown in that region without this protection.

This is well illustrated by the following table which is based on a 2/3 per cent count of 48 seedbeds, each four by twelve feet. The seedbeds sown in June, 1935 and the count made in the fall of that year.

iable seed sown er sq. ft.*	Expected stand of 1-0 seedlings per sq. ft.	Actual stand of 1-0 seedlings obtained per sq. ft. of bed	
		Half Shade	No Shade
56	40	30.5	36.0
86	60	49.0	60.5
112	80	68.0	74.0
140	100	89.5	88.5
168	120	102.5	91.5
196	140	111.0	113.5

*sed on the laboratory germination per cent of 43.5 per cent in 45 days.

It will be seen that in all but two cases, the unshaded beds produced a ter stand of seedlings than did those protected by half-shade. The average io of viable seed sown to the number of 1-0 seedlings produced is 1.72 and .0 for the shaded and non-shaded beds respectively. In other words, for ry 100 seedlings produced in the shaded beds, 172 viable seeds had to be n while in the non-shaded beds only 160 viable seeds were required.

Since more effective use of Ponderosa pine seed can be obtained by tting the shade and the resulting seedlings can thus be produced at a lower t, it is evident that the results of this study have considerable practical nificance.

May, 1936

TAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL, MINNESOTA

Rabbits Cause Heavy Damage to Plantations in Brushy Areas

The chief reasons for the high mortality among forest plantations in [illegible] trees [illegible]. In brushy areas in northern Minnesota rabbit damage is often responsible for the complete failure of whole plantations. This is well illustrated by results of experiments on the Superior National Forest.

A six-acre tract was planted in September, 1934, half with [illegible] pine and the balance with 2-0 Norway pine. The moderately heavy cover of willow, alder, hazel and aspen was cleared from half the area planted to each species while on the remainder it was left uncut.

Before planting was completed, some of the seedlings in the brushy area had been injured, and within a month numerous nipped trees were found. The results of an examination made in October 1935, are shown below.

[illegible]	Treatment of brush	Survival per cent	Rabbit damage in per cent (Living trees only)
Jack pine	Cut	84	21
Jack pine	Not cut	44	97
Norway pine	Cut	78	1
Norway pine	Not cut	66	33

The figures indicating rabbit damage even in the case of jack pine on the [illegible] area do not tell the whole story. The poor survival of this species and losses in Norway pine can be largely attributed to injuries caused by this [illegible].

Although the rabbits seem to prefer jack pine to Norway pine, it is likely [illegible] the latter seedlings grow sufficiently to become conspicuous they will [illegible] attacked. Most damage where the brush was cut occurred near edges of the open[illegible]

Another Norway pine plantation on the same Forest shows even more strikingly how much damage these animals can cause in a short time. In this case the seedlings were planted partly in brush and partly in an adjacent grassy meadow [illegible] May 1932. In October of the same year, 77 per cent of the trees planted under brush but only 1[illegible] per cent of those in the meadow had been nipped. By 1935, the seedlings under brush had completely disappeared, while those in the openings were making appreciable height growth.

It is thus evident that plantations cannot successfully be made in brush[illegible] in times of high rabbit population, unless some provision is made to [illegible]t them from these animals. One method of protection is to change the cover conditions.

MAINTAINED BY THE UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

No. 117

Winter Injury to Plantations

The use of forest planting stock of unknown origin is very much of a gamble. Although plantations made with such stock may show excellent survival and growth during their early life, in later years some unforeseen factor may arise that will cause heavy losses.

This is well illustrated by the results from several plantations of white pine and red oak located at the Station's Upper Peninsula Branch at Dukes, Michigan. During the first few years the survival and growth of this stock, which was of unknown origin, was fully as good as that in other plantations grown from local seed. The results of the past few years tell a different story, however.

Many of these trees have now attained a height of more than four feet (the maximum depth of snow), and their tops are thus subjected to the extreme winter conditions common to northern Michigan. As a result, about half of the white pines and nearly all of the oaks have been frozen back to snow line. Each summer a new shoot has replaced the frozen leader only to be killed in turn during the following winter. In no case were the trees killed outright, probably due to the protection afforded by at least one or two feet of snow during periods of extremely low temperatures. Many of the white pines have succombed, however, to the effects of subsequent freezing, while trees surviving, both pines and oaks, have been deformed and stunted.

The results are of considerable significance for they not only point out the folly of using stock of unknown origin but also show that good early survival cannot be depended on as a measure of a successful plantation.

May 1936

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL, MINNESOTA

Large Quantities of Seed Produced by Northern Hardwood Forest

Some interesting figures testifying to the seed-producing power of the [illegible]thern hardwood forest are revealed by an analysis of the "catch" of seed [illegible]ps located at the Station's Upper Peninsula Branch at Dukes, Michigan. Al[illegible]ugh it is known that some trees of this type produce seed every year, and [illegible]vy crops at intervals of four to seven years, the magnitude of the seed [illegible]duction has heretofore only been guessed at.

One set of five traps, placed under virgin hardwood forest, and another [illegible]er an area of this type which had been selectively cut, show that during [illegible] year ending September 1, 1935 (which included the excellent seed year of [illegible]4) the average seed production ranged from over 8 million per acre in the [illegible]ective cutting to over 11-1/2 million in the virgin forest. A summary by [illegible]cies is presented in the following table.

Average Number of Seed Produced Per Acre [illegible] 1, [illegible]-Sept. 1, [illegible]

Species	Virgin Forest	Northern Hardwood Type Selective Cutting
Sugar Maple	8,560,000	4,302,000
Yellow Birch	2,700,000	3,739,000
White Spruce	118,000	19,000
Red Maple	102,000	14,000
Ironwood	51,000	27,000
Cedar	32,000	17,000
Elm	7,000	---
Total	11,570,000	[illegible]

Although only a small fraction of this large quantity of seed may ever [illegible]rminate, it is evident why the forest floor in this type is usually carpeted [illegible]th young seedlings and why reproduction is not the problem here that it is [illegible] other types.

[illegible]. 118 May, 1936

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LAKE STATES FOREST EXPERIMENT STATION

S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE

UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 119

Windfirmness of Black Spruce in Residual Stands

ack spruce is notoriously susceptible to windthrow. Yet it is so highly rised for pulpwood that it is considered to be a most desirable tree to rpetuate. This tree occurs largely in swamps and in pure stands. In rtheastern Minnesota, however, black spruce is a common associate of jack ne and aspen, but because it is slower growing, frequently occupies a bordinate position in the stand, many trees being under merchantable size en the main stand is ready to cut. Such an understory of immature black ruce trees may number between 200 and 300 per acre, and often are relied on to furnish the nucleus of another crop some twenty to thirty years llowing the cutting of the jack pine. Observations and experiments in tting some of the jack pine from such mixed stands conducted by this ation over a period of several years, however, lead to the conclusion at the spruce understory may not be as desirable for this purpose as is mmonly believed.

ack spruce has very shallow roots and is hence very subject to windthrow; derstory trees seem to be even less windfirm than the species as a whole. nce many trees 3" or 4" in diameter can easily be up-rooted simply by cking them back and forth, it can readily be imagined what happens when strong wind strikes a stand from which half or two-thirds of the overstory s been removed. In the case of the Keeley Creek plots on the Kawishiwi perimental Forest, where between 60 and 70 per cent of the jack pine overstory was cut 65 per cent of all spruce trees 4" DBH and over were blown down n somewhat over two years. Even trees as small as 2" DBH were windthrown.

re black spruce stands on upland soils are likewise subject to excessive nd damage when cut heavily. In a light cutting, however, on the experintal forest made in 1934 where only 25 per cent of the merchantable volume s removed, the residual stand has thus far successfully withstood the onaught of the wind.

e lesson to be gained from these results is that foresters in northeastern nnesota should neither leave black spruce of merchantable size when making avy cuttings, nor rely too much on the understory spruce to furnish a ture cut unless the cuttings are light.

ay, 1936

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · FOREST SERVICE

Effect of Spring Fires on Sprout Oak Stands

Although spring fires in sprout oak stands are commonly believed to cause but little direct damage, the results of recent burning experiments at the Michigan Forest Fire Experiment Station* point to the contrary. Not only are all of the smaller trees killed outright and the larger trees badly fire-scarred, but the character and composition of the stand is also considerably changed as a result of a single fire. This is well illustrated by the following table:

Number of Trees or Sprout Clumps Per Acre

	Jack pine	Oak (trees)	Oak (clumps)	Aspen	Red Maple (clumps)	Fire Cherry (clumps)	1/ Misc.	Total
Stand before burning	4	73	198	64	11	9	104	463
Stand first fall after burning	0	93	282	414	11	11	100	911

1/ Serviceberry, witch hazel, willow and hawthorn.

The major results of the fire are as follows:

1. Practically all trees and sprouts under 4" were killed back.
2. All of the larger oaks surviving were severely damaged.
3. Conifers, jack pine in this case, were eliminated from the stand.
4. The number of oaks, both trees and sprout clumps, and the number of aspen stems increased greatly.
5. Aspen replaced oak as the dominant species on a site where it has no future.
6. The total number of trees and sprout clumps doubled.

It is thus evident that aside from the losses caused by the destruction of most of the trees, fires in sprout oak stands encourage the development of inferior growth. Not only are the better species replaced by inferior ones and trees of seedling origin supplanted by sprouts, but the great increase in number of sprout clumps per acre tends to reduce the ultimate quality of timber that can be grown.

*Maintained at Roscommon, Michigan, in cooperation with the Michigan Department of Conservation.

MAINTAINED AT ST. PAUL I, MINNESOTA, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA
No. 121

Damage from Rabbits - A Consideration in Shelterbelt Planting

In an earlier Technical Note (No. 109) it was pointed out that the common rabbit of the northern Lake States, the snowshoe hare, shows a decided food preference for some woody plants. In an examination of Oklahoma shelterbelts, the Station found that rabbits in the Plains Region also prefer some trees and shrubs to others, and exhibit these preferences to the great detriment of some of the planted trees.

This is illustrated by the accompanying table which is based on data from two shelterbelts planted in January, 1936. Both of these plantations, although at some distance apart, were located on land used for raising cotton and kaffir corn and surrounded by considerable pasture land composed of blue-stem grass and sage brush. The latter formed excellent cover for jack rabbits and cottontails, both of which were exceedingly numerous.

	Plantation 1		Plantation 2	
Species	Severe 1/ Injury	Moderate 2/ Injury	Severe 1/ Injury	Moderate 2/ Injury
	Percentages of Trees Injured			
Osage orange	0	0	-	-
Russian mulberry	0	4	0	5
Black locust	-	-	0	4
Soapberry	-	-	0	5
Green ash	2	2	-	-
Cottonwood	-	-	5	5
Honey locust	5	5	35	15
Desert willow	10	10	30	20
Soft maple	15	10	-	-
Hackberry	20	20	20	20
Western walnut	25	15	-	-
American elm	-	-	50	10
Tamarisk	50	20	20	20
Catalpa	-	-	60	10
Chinese elm	75	17	-	-

1/ Includes complete girdling or complete cutting off of stem at ground line.
2/ Includes partial girdling or nipping of side limbs.

Since it is readily apparent that some species are much more severely damaged than others, the selection of the proper trees and shrubs for planting in areas heavily populated by rabbits should, therefore, do much to minimize the damage caused by these animals.

MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA
January, 1937

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · FOREST SERVICE

New Device Measures Use of Water by Trees

The success of forest planting in the prairie-plains region depends in a large measure on the use of trees and shrubs which can withstand severe drought conditions. The ideal species for this purpose would be those economical in their use of water, those which could produce large amounts of foliage (thus having a high windbreak value), for a minimum amount of water.

In order to determine how the various trees and shrubs now being used for Plains planting meet these requirements, an apparatus has recently been built by Messrs. Minckler and Bates of the Station staff, which actually measures the amount of water used by small trees under field conditions. This consists of a chamber 4 feet high and 2 feet in diameter, resembling a bird cage made of cellophane. After covering the ground under the tree with canvas to prevent evaporation from the soil, the chamber is placed over the tree to be measured. An exhaust pump maintains a continuous flow of air through the chamber. A sample of this air is drawn through a series of 6 drying tubes which are weighed at intervals to see how much moisture is absorbed. To determine how much of this moisture consists of that lost by the tree through its leaves, a comparison must be made with air not affected by any particular vegetation. For this test the apparatus is set up at a nearby point and the air moisture measured in the same way. The difference between the two readings represents the amount of water lost by the tree through its leaves.

Field trials made with the apparatus during the past summer show interesting features concerning the water use of various species. Since Chinese elm roots widely and vigorously, has leaves which persist throughout a long growing season, and makes rapid woody growth, it might naturally be expected to cause a heavy drain on soil moisture. This is well borne out by tests made with the apparatus in Oklahoma. During hot dry weather, a Chinese elm 3.3 feet in height lost water at the rate of 2 pounds per hour (1.4 liters or about 3 pounds per hour per square meter of foliage) in the morning but less than a fifth as much in the late afternoon.

None of the other species tested under similar conditions approached such a high rate as Chinese elm. Yet this species, in the juvenile stages, outclasses practically all other trees in withstanding drought, as shown by actual field survival tests. The question is whether, in the long run, Chinese elm is likely to prove one of the most desirable species.

It is believed that the apparatus will be of considerable help in obtaining a new "slant" on the performance of the various species, and probable performance when drought becomes a critical factor.

No. 122 February, 1937

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION

U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE

UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 123

Subsoiling Greatly Increases Tree Survival in Plains Region

Tree planting in the Plains region, because of the severe climatic extremes, is a somewhat risky undertaking and can be done successfully only if care is taken to conserve moisture. In addition to cultivation during the first few growing seasons, careful planting is extremely important.

One of the newest developments along this line is the application of subsoiling, a practice long used in fruit culture. This was done on a large scale during the spring planting season of 1936 by the United States Forest Service in the Plains region in connection with the establishment of shelterbelts. The results were very gratifying.

The method consists of loosening the soil (lifting, but not turning it over) in a band about 8 to 10 inches wide and 12 inches deep. This is accomplished by means of a narrow lister bottom drawn by a tractor. A "packing" device attached directly behind the subsoiler helps to fill up the narrow trench left by the latter and to level the ground surface, thus avoiding excessive looseness and subsequent drying out of the soil. The subsoiling is usually done in parallel lines, 8 feet apart, along which the trees are planted; the areas planted in most cases have previously been plowed.

The results of an experiment carried on by the Station during 1936 to bring out the advantages of this method are strikingly demonstrated in the accompanying table. Subsoiling was done on February 27, and the area planted on February 28, and March 2. To eliminate any error due to variability in planters, trees of the same species were planted by the same man in both subsoiled and unsubsoiled rows.

Effect of Subsoiling on First-Year Survival
and Growth of Trees Planted on Fine-Textured Soils
Mangum, Oklahoma

Age and species of planting stock	Subsoiled rows				Rows not subsoiled			
	No. trees planted	Ave. h'gt. October, 1936	Vigor October, 1936	Survival October, 1936	No. trees planted	Ave. h'gt. October, 1936	Vigor October, 1936	Survival October, 1936
		feet		percent		feet		percent
1-0 Osage orange	270	1.5	Good	64	239	1.0	Poor	30
1-0 Honey locust	248	2.5	Good	87	246	1.5	Fair	59
Cottonwood Wildlings	243	3.0	Good	24	248	2.5	Good	1
Average survival				58.3				30.0

As can be seen from the table, subsoiling increased average survival of the trees about 30 percent. In addition, height growth was markedly greater and vigor generally better than that of trees in unsubsoiled rows. Speed of planting was increased by about 30 percent, and subsequent root studies showed that trees in subsoiled rows invariably had a wider, and sometimes deeper, spread of roots.

February 1937

MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES

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UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 124

Forest Litter and Gravelly Soils - Effective Conservers of Water

Experiments now being carried on at the Station's Soil Erosion Branch* show that such widely different kinds of cover as forest litter and gravelly surface soil are effective conservers of water. Not only is run-off greatly reduced but the water thus saved seeps into the ground where it replenishes local supplies.

For these studies, water-tight tanks, 10x10 feet in size, were filled with uniform soil to a depth of four feet. These tanks, known as lysimeters, were so made that run-off and water percolating through the soil layers can be accurately measured as a percent of the total precipitation. Two were planted to two-year-old native hardwoods (oak and black walnut), one to two-year-old Scotch pine, and a fourth was covered with a two-inch layer of coarse gravel. The three lysimeters planted to trees were mulched to a depth of about 2½ inches with forest litter from undisturbed hardwood and pine stands; the gravel-covered tank had no vegetative cover of any kind.

During the five-month period, July 1 - November 30, 1936, a total of 13.7 inches of precipitation fell on the lysimeters. What happened to this rainfall is shown in the following table:

Cover	Percent of Precipitation		
	Lost as run-off	Percolating through soil	Absorbed by soil or used by vegetation
Hardwoods	3	3	94
Hardwoods	3	Trace	97
Scotch pine	2	Trace	98
Gravel	3	49	48

As will be noted, the gravel and litter-covered tanks acted similarly in that they showed only a negligible amount of run-off. The greatest difference between them occurred in the use made of the precipitation after it had penetrated the soil. Whereas almost half of the moisture falling on the "gravel" plot eventually percolated through the soil, only a trace was recovered from the litter-covered plots. This difference represents the amount of the precipitation used by the planted trees. Furthermore, the "gravel" lysimeter began to yield percolation on August 28, but the other lysimeters showed no percolation until November, long after growth had ceased.

These results indicate that during the summer months when the vegetation is fully developed, forest vegetation uses a large part of the precipitation trapped by the litter and evaporates it into the air. During early summer and late fall, however, when growth is practically nil, a reserve supply of moisture is built up in the soil layers.

February 1937

* Maintained at LaCrosse, Wisconsin, in cooperation with the University of Wisconsin and the Soil Conservation Service, U. S. Dept. of Agriculture.

MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 125

Heat More Injurious than Lack of Moisture during Drought

Although it is usually recognized that drought periods are accompanied by extremely hot weather, mortality in forest plantations in such years is usually considered to be due to lack of moisture. Recent studies made by the Station, however, show that in some dry years extreme temperatures cause considerably more loss of trees than the shortage of rainfall. This is well illustrated by the following table, which is based on data obtained during the late summer of 1936 from plantations on the Huron National Forest.

Species	Age (from seed)	Causes of mortality			Basis - number of plantations
		Heat	Lack of moisture	Other	
	Years	Percent	Percent	Percent	
Jack pine	2½	74	26	-	10
Norway pine	7	58	41	1	15

Heat injury is evidenced by a discolored ring of "cooked" cambium which is found on smaller trees (those under 1/2 inch in diameter) usually within one inch above the soil surface. On larger trees the injury takes the form of lesions on the southwestern side of the trees. In a few cases girdled trees were found which had dead tops, but living roots. This would definitely indicate that death was not due to lack of moisture.

That heat injury was the most important source of loss in the above plantations during 1936 is not surprising in view of the abnormally hot weather which occurred on the Forest; thermograph records taken in an opening in a typical plantation show that on one day a maximum soil-surface temperature of 175° was reached, with a continuous 8½-hour period of over 130°.

February 1937.

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LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA
No. 126

Watering Reduces Soil-Surface Temperatures

During the hot dry summer of 1936, many nurserymen in the North Central region turned on their overhead sprinkling systems during the day, with the idea of reducing the excessive soil-surface temperatures which would cause direct heat injury to small seedlings.

The effectiveness of such a measure depends, of course, on (1) wind, (2) degree of cloudiness, (3) humidity, (4) air and soil temperature, (5) soil texture (water-holding capacity), (6) soil color, (7) soil moisture content before and after watering, (8) length of watering time, (9) time of application, and (10) type of shade used.

To test the effectiveness of such watering, a brief study was made by J. H. Stoeckeler in the U. S. Forest Service nursery at Towner, North Dakota, on July 6, 1936. The soil there consists of 6-8 inches of almost black, loamy sand (10 percent silt and clay) over a substratum of sand, and due to the dark color, becomes very hot.

As is shown in the graph below, daytime watering in this nursery has been found of considerable aid in reducing soil-surface temperatures and attendant heat injury to small seedlings of ponderosa pine, 30 to 50 days old, which showed definite lesions on the southwest side of the stems when the soil-surface temperatures were about 120° F.

The graph also indicates that to get the maximum cooling benefit of such watering on loamy sand or light sandy loams, the overhead system during mid-summer should be operated for an hour twice during the day. These periods preferably should begin at about 10:30 a.m. and at 1:30 p.m.

In some nurseries with soils of finer texture and consequently higher water-holding capacity, one watering period of about 2 hours, beginning between 10 and 11:30 a.m., would probably suffice to hold down the soil-surface temperature below the danger point. The presence or absence of half shade and others of the nine factors mentioned above would, of course, also determine the time and length of watering period which is most effective in a given nursery. This can be easily determined by any nursery superintendent with the aid of a few thermometers which are laid on the surface of the soil in a watered and unwatered block and read periodically.

Since the water so used is largely evaporated, daytime watering should be considered largely as a method of "cooling" the soil surface and not for supplying water for plant growth. Watering for the latter purpose is more effective if done at night.

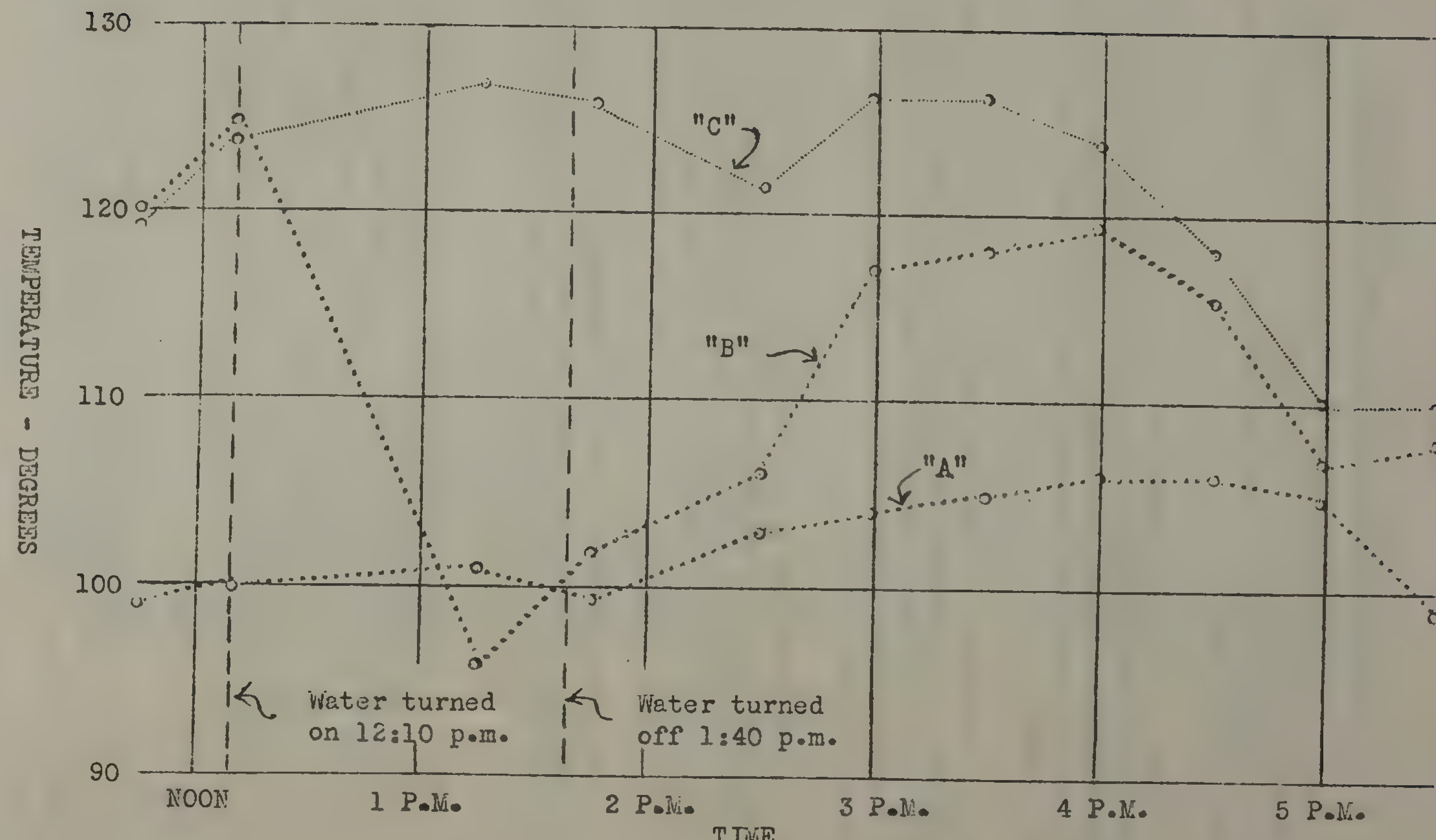
September 1937

(over)

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

EFFECT OF WATERING ON SOIL-SURFACE TEMPERATURES

Towner, North Dakota
July 6, 1936



"A" Air temperatures in shade.
"B" Soil-surface temperatures in sun with $1\frac{1}{2}$ hours of wetting.
"C" Soil-surface temperatures in sun with no wetting.

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Fence Posts a Million-Dollar Crop in Michigan

The value of the annual cut of fence posts in Michigan is well over a million dollars, according to the Forest Survey which the Station has recently brought to a close in that State. To keep the 392,000 miles of farm, vineyard and railroad fencing in good condition requires nearly 8½ million posts a year.

The following tables gives the amounts of various wood species and of steel now in use and the estimated future requirements of the same materials. The variations between present and probable future use are due in part to differences in durability and in part to changing customs.

Species	Posts in use		Annual replacements (est.)	
	Number	Percent	Number	Percent
White cedar	65,450,300	55.5	2,837,200	33.7
White oak	37,143,000	31.5	3,940,200	46.8
Aspen	445,000	0.4	345,200	4.1
Elm	487,300	0.4	244,200	2.9
Red oak	1,472,600	1.2	193,600	2.3
Tamarack	2,497,400	2.1	117,900	1.4
Miscellaneous hardwoods	1,411,000	1.2	252,600	3.0
Miscellaneous conifers	541,300	0.5	8,400	0.1
Steel	8,420,600	7.2	479,900	5.7
TOTAL	117,868,500	100.0	8,419,200	100.0

Cedar has always been the favorite wood for posts in Michigan, but in recent years, due to a decrease in the supply as well as to the depression, farmers have been turning to other woods which could be cut on their own farms or nearby. As a result the use of oak has been increasing rapidly, and even such species as aspen, ash, and elm have come into common use.

About 23 percent of the posts in use by the railroads are steel, and of all posts in the State, over 7 percent are of this material. However, steel posts cost twice as much as cedar and their life is not much longer. This probably accounts for the fact that only 5.7 percent of current replacement ar of steel.

At 15 cents per post, the annual cut has a market value of $1,190,895. Assuming that a man can produce about 50 posts per day, the woods work thus amounts to a total of 158,786 man-days, or a month's work for 6,350 men.

The annual harvest of this crop is therefore an important contribution of the forests to farmers and to woods workers in Michigan.

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TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
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No. 128

Seed Origin Affects Survival of Green Ash in the Nursery

In connection with the large-scale reforestation activities now under way in this country, it has been frequent, if not common practice to obtain seed for nursery stock from whatever source was possible, even though that source might be a great distance removed from the area to be planted. Cheapness rather than quality has been the guide usually followed.

The fallacy of using such seed is well illustrated by results obtained with green ash seedlings from different sources planted at the Station's North Dakota branch at Denbigh. In the spring of 1935, 69 small lots of seed collected in various states of the prairie plains region in the fall of 1934, were sown in the experimental nursery. Survival counts were made in September 1935 and again in July 1936. The latter are presented in the following table:

State	Number of lots of seed	Total number of trees	Average weighted survival percent
North Dakota	25	294	67
South Dakota	12	532	62
Nebraska	21	913	48
Kansas	8	243	43
Oklahoma	3	132	7

As will be observed an almost regular reduction in survival was shown by the seed progressing from north to south. Most of this loss was due to the inability of the seedlings from southern seed to withstand the winter of 1935-36 at Denbigh. This occurred in spite of a fairly good snow cover on the seed beds over much of the winter. A portion of the loss was, of course, caused by drought, but since all the trees were occasionally watered, this was of little importance.

As the trees become taller and get above the general snow level, it is probable that the seedlings of southern origin will continue to suffer losses. It is therefore apparent that seedlings of local origin even in the early stages of development have a considerable advantage over seedlings from other sources; at least, moving seed for long distances is apt to be dangerous.

September 1937

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No. 129

Extensions in the Range of Lake States Trees

Knowledge of the general distribution of forest trees is basic to the successful handling and propagation of forests. Due, however, to the relatively short time that this country has been settled, the ranges of many of our native American trees are imperfectly known. The Federal Forest Service is therefore constantly collecting data on the occurrence of different species and presenting this information in the form of range maps.

During the past few years members of the staff of this Station, particularly Messrs. Kittredge and Roe, have extended our knowledge in the distribution of our Lake States trees. The most important of these are given in the following table:

Species	Locality	Previously known extreme range in that locality*	New occurrences	Extension in range: Distance (Miles)	Extension in range: direction
Silver maple	Upper Peninsula Michigan	Southern Wis.	Mouth of Ontonagon R.	250	north
	Northern Minn.	Southern Minn.	Lower Red L.	250	north
Rock elm	Northern Minn.	Northern Iowa	Northern Itasca co.	300	north
	Northeastern Wisconsin	East-central Wisconsin	Wausaukee, Marinette co.	300	north
Jack oak	Northwestern Minnesota	Southern Cass co.	Lower Red L.	100	north-west
	Northeastern Minnesota	Carlton co.	Tower, St. Louis co.	120	north-east
	Upper Peninsula Michigan	Northern Wis.	Trout Creek, Ontonagon co.	50	north
White oak	Northeastern Wisconsin	North-central Wisconsin	Dunbar Twp., Marinette co.	50	north
Red oak	Northeastern Minnesota	East-central Minnesota	Cramer, Lake co.	50	north-east

*As given in Sudworth's "Check list of the forest types of the United States, their names and ranges."

Especially notable is the extension of the range of hemlock to the eastern side of Mille Lacs in central Minnesota, the westernmost station known for this species in North America. Although in former years hemlock was found at several scattered locations in Pine, Carlton, and St. Louis counties, the great fires of 1918 destroyed all traces of those trees, and until recently this graceful evergreen was believed lost to the State. Other areas where hemlock occurs have since been found east of the Mille Lacs trees so the tree is probably not as near to extinction as had been thought.

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA
September 1937

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Forest Cover Keeps Frost Line at Shallow Depth

Recent observations carried on by H. F. Scholz at the LaCrosse Soil Erosion Station show that in the forest, frost penetrates the soil to a much less depth than in open fields and pastures.

During the winter of 1936-37, measurements of the depth of frost were taken at each of ten stations in an ungrazed woodlot and also in an open pasture consisting of closely cropped bluegrass sod. The measurements which were obtained by means of a standard soil sampling tube first were taken fortnightly, and later at more frequent intervals.

The average depth of frost as well as the average depth of the snow mantle for both cover conditions is illustrated in the charts below.

The frost in the open pasture was found to penetrate to an average depth of 10 inches, that in the woodlot to a depth of only 4 inches. Although the snow was somewhat deeper in the woods than in the pasture, this difference was not enough to account for the great difference in frost depth.

The manner in which the frost left the ground is also of interest. In the open pasture, the direct rays of the sun and the above-freezing air temperatures progressively thawed out the soil, beginning at the surface and working down into the subsoil until the frost had completely disappeared. In the woodlot, however, at those points where frost still occurred,* thawing evidently took place from the subsoil up, for in no case did the ice crystals disappear in the surface soil prior to the thawing of the lower layers. Yet all frost had disappeared in the woods two days before the pasture soil was completely thawed.

*Only for about a four-week period during January was the soil frozen at all ten stations in the woodlot.

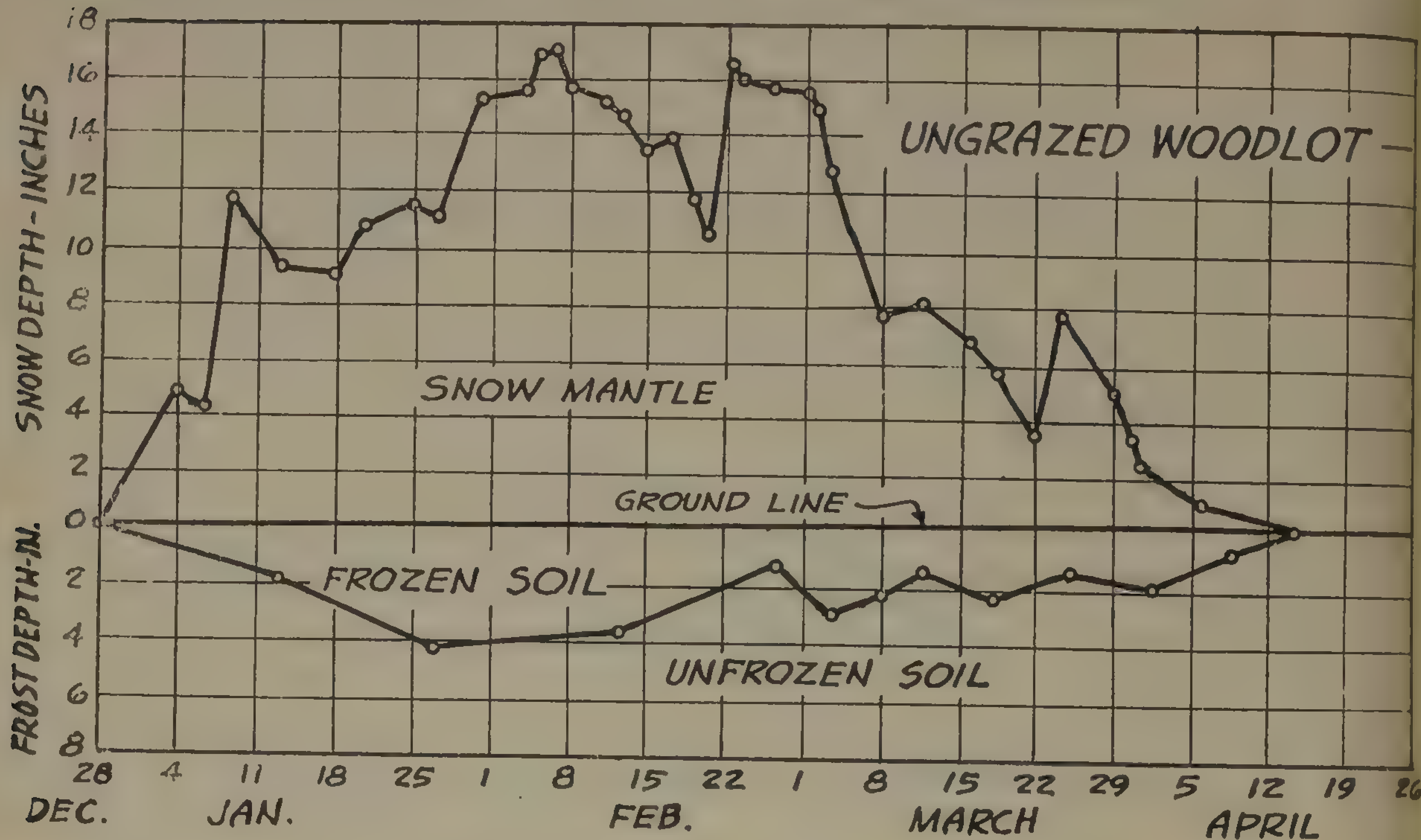
No. 130

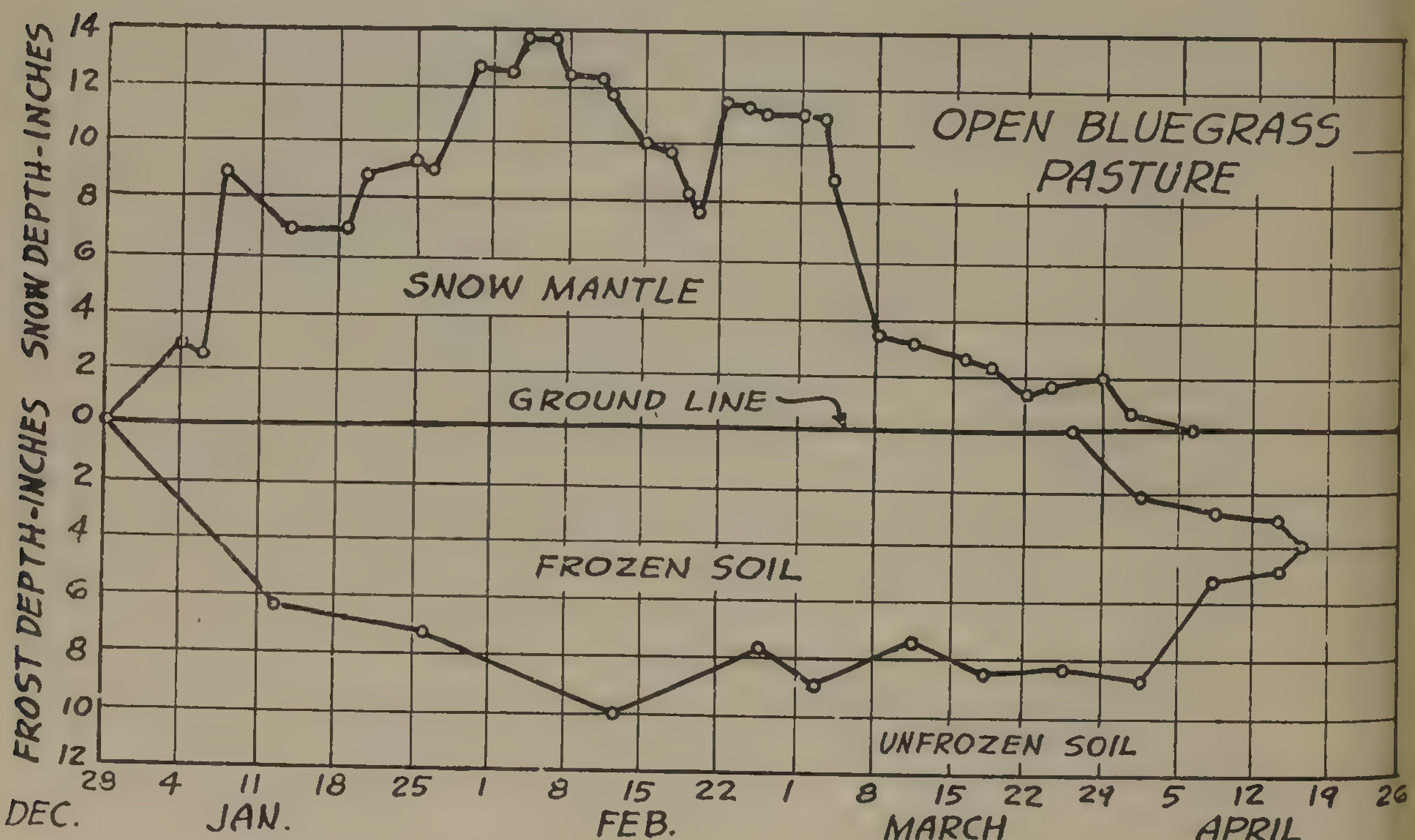
September, 1937

(over)

AINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

AVERAGE SNOW AND FROST DEPTH MEASUREMENTS
DEC. 28, 1936 - APRIL 26, 1937
LA CROSSE, WIS.





TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Is Spring or Fall the Better Planting Season?

The relative merits of spring and fall for planting in the Lake States have been investigated in a comprehensive experiment carried out on the Superior National Forest by the Region in cooperation with the Station. The results of this experiment offer the most conclusive and convincing evidence for the belief that spring is the better season for planting operations, at least on the Superior National Forest.

This experiment was conducted at eight different C.C.C. camps on the Superior. The stock used was 2-0 red pine and the planting was done in the fall of 1935 and spring of 1936.

Planting was done on light, medium, and heavy soils and under three degrees of cover. The different soil and cover conditions were represented equally in both the spring and fall plantings. The results to be discussed below may be considered statistically significant and conclusive.

On all three soil classes and cover densities, spring planting resulted in better survival; twice as good on the average, in fact. On heavy soils, spring planting was nearly six times as good. With spring planting, survival increased with the change from light to heavy soils, while for fall planted trees, survival was considerably lower on heavy soils than on light and medium.

It should be understood that these results are from only one year's plantings. However, the fall season in which the planting was done was favored by conditions better than average, while the spring season was immediately followed by the severe drought of 1936. Furthermore, the evidence from this experiment is supported by that from several other less extensive tests, so it would seem reasonable to expect as great or even greater differences in the same direction in other years.

The facts learned from this experiment can be literally translated into recommendations to be followed when drawing up planting plans. First, as much of the planting as possible should be done in spring; second, what planting is done in the fall should be confined to light and medium soils.

No. 131

September, 1937

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 132

Does Freezing Injure Planting Stock

Forest planting is always done in the spring or fall, at which seasons unexpected frosts often occur. It is not always possible for a crew to plant all the stock which has been delivered to it in any given day. This means that the stock must be stored overnight and possibly exposed to below-freezing temperatures. The next morning the question always arises of whether or not the stock has been injured enough to warrant discarding it.

A test was made in the laboratory of the Lake States Forest Experiment Station at St. Paul, in order to find an answer to this always annoying question. Small bundles of planting stock were exposed to cold in a special freezing chamber, while comparable bundles were kept in cold storage. Stock of two species, 2-0 jack pine and white spruce, were tied in bundles of thirty trees each. Some were placed in the freezing chamber at a temperature of 18 degrees F. below freezing (+14° F.); the remainder were kept in a cold room at 9 degrees F. above freezing (+41° F.). The bundles were divided into three groups, one being exposed for a period of 18 hours, another group for 1 day, and the third for 3 days. After removal from the cold chambers, the plants were soaked in cold tap water and then heeled-in in the greenhouse beds. Three weeks later they were lifted and studied to determine how much damage had been done. The jack pine was not injured; nearly all plants had put new growth on tops and roots. The spruce, however, suffered quite heavily, 40 to 50 percent of the trees in the below-freezing room having been killed, and another 15 to 20 percent slightly injured. Even the plants stored above freezing were killed to the extent of 30 to 40 percent. The damage was nearly equal for all three exposure periods, only slight and inconsistent increases being noticed with increasing periods.

As these trees were exposed to the cold while packed in quite small bundles compared with the sizes ordinarily used under field conditions, it is probable that greater damage was done than might occur in actual practice. However, it is safe to summarize by saying that jack pine is not likely to be injured by short exposures to below-freezing temperatures, but white spruce may be damaged quite severely and efforts should be made to avoid storing this species at freezing temperatures or even above.

September 1937

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 133

Food Habits of Minnesota Deer

To learn why deer in the north woods are fat and in good condition during the fall hunting season and thin and weak in the late winter, the stomachs of 22 deer killed in the fall and 52 killed in late winter were collected and the contents analyzed by Shaler E. Aldous of the Biological Survey. These examinations revealed that 45 plant species were eaten during the fall and only 25 in the winter. Although evergreens, including balsam fir, pine, white cedar, and spruce, formed only a little over one-fourth of the fall diet, they composed almost three-fourths of late winter feed. White cedar, the most valuable of the deer browse species, increased only 3 percent in the winter diet, the greatest bulk being derived from balsam and pine. Willows and poplars formed 29 percent of the fall diet but decreased to less than 4 percent of the late winter diet. Species of the heath, honeysuckle, and birch families were minor items of diet during both periods.

The conclusions drawn from this study in conjunction with available browse surveys were: (1) that the winter carrying-capacity for deer in northeastern Minnesota is on the decline; (2) the browse species that form the greater part of the winter food are not of the greatest nutritional value; (3) many of the choice browse species are either characterisitcally rare or are becoming unattainable due to heavy browsing in previous years; (4) balsam fir, which may be good deer browse when eaten in moderate amounts in combination with more nutritious foods, is not capable of maintaining good health when eaten alone or in too great a proportion to other foods; (5) maple brush is the most generally available of the choice browse species in this area. Other desirable species may be abundant locally but are more spotty in their distribution; (6) the variation in the availability of certain browse species in different concentration areas indicates that management practices will have to be developed for and applied to rather limited areas.

February 1938

MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 134

White Spruce on Alkaline Soils

While on a seed collecting trip in Canada, J. H. Stoeckeler took soil samples from profiles in two thrifty stands of white spruce, *Picea glauca* (Moench.) Voss, 80 and 50 years in age respectively, located near Riding Mountain National Park and the Spruce Woods Forest Reserve in the Province of Manitoba. Analysis of these samples is at variance with the theory that spruce must have acid soil to thrive. The analysis, among other things, showed pH's ranging from 6.2 to 8.4 at various depths under one stand and from 6.4 to 8.2 under the other. The limited rainfall (normal 17 inches) apparently has been insufficient to leach the abundance of calcium carbonate, which tests disclosed, to any great depth, with the result that the soil is more typical of the sub-humid Great Plains than of the true forest regions. That this condition has practical significance is reflected by the fact that white spruce is one of the few conifers recommended for planting in the prairie provinces by Canadian authorities. It seems, therefore, that white spruce can grow under a greater range of soil conditions than has been commonly supposed.

February 1938

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 135

Control of Snow Drifting by Design of Windbreaks

Snow profile measurements which were taken periodically during the winter of 1936-37 both to windward and leeward of several windbreaks in North Dakota, serve to illustrate very concretely the effectiveness of several types of groves in catching and distributing snow. A 46-foot-wide grove of box-elder with a dense outer row of shrubs (caragana) on the windward side piled up practically all the snow within the windbreak itself, with the peak (which reached 96 inches) of the drift occurring nearly in the center of the grove. There was very little increase in snow depth on the leeward side.

On the other hand, a wide (115 feet) but open grove consisting entirely of cottonwood caused a little drifting on the windward side, with the peak of the drift reaching 20 inches in height about 20 feet to windward of the grove, and additional drifting on the leeward side where the snow piled up to a depth of 24 inches about 30 feet beyond the grove. Both groves were located so as to be comparable as regards topography, type of crop, and method of harvesting to windward of the grove. The total snowfall on the level up to the time measurements ceased was about 5 inches.

These results illustrate the necessity for designing windbreaks carefully so that they may effectively serve the function of either preventing drifting in roads or causing drifting in certain spots such as garden patches.

For instance, in locating a windbreak near a road or around farmstead buildings, the first row on the windward side should be at least 100 feet away from the road or buildings and should consist of dense, low-growing shrubs such as caragana.

February 1938

TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

No. 136

How to Obtain Effective Dispersal of Jack Pine Seed

Since jack pine cones on living trees do not open and, therefore, do not disperse their seed to any extent, three methods were tried out by R. K. LeBarron on the Superior National Forest to find a way to combine good cone opening with fairly even distribution of seed over the area.

In the first method, jack pine branches were lopped and scattered; in the second, the tops of felled trees were left intact on the ground; and in the third, standing trees were girdled. Seedfall was measured by enclosing selected conebearing twigs on the trees and in the slash with ordinary window screen. Twenty-five such cages were used and 230 cones enclosed in all.

The seeds collected in these cages were counted at frequent intervals except during the winter, for a period of 29 months. The cones on the lopped branches yielded a total of 24.56 seeds per cone, the felled trees 2.87 seeds, and the girdled trees only 0.23 seeds per cone.

July and August were the months of greatest seedfall, although some seed was released during June, September, and October. The factors that appeared to be most influential in causing seedfall were temperature and precipitation. The majority of the seed fell during periods when the ten-day mean maximum temperatures were over 75° F. Within these warm periods precipitation also had a noticeable effect.

As a result of these experiments it appears that the only effective method of securing jack pine seed dispersal is to lop and scatter the branches. It may be necessary to leave the slash on the ground for two or three years in order to obtain as many of the seeds as possible.

February 1938

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Peat or Sand for Covering on Spruce Seedbeds?

In the spring of 1936 one spruce seedbed in the experimental nursery at Cass Lake was covered with a light layer of sand and another with peat to find out if such coverings would hasten germination of spring-sown spruce. The amounts applied were: peat, 1/4 inch, and sand, 1/8 inch. The seed was carefully weighed so as to get the same amount in both treatments. All beds were watered twice before germination took place. The peat-covered spruce, both black and white, began to germinate two days before the sand-covered, but as a whole the sand-covered beds finished germination as early as the peat-covered beds, and a very good stand resulted in each treatment. On July 29, after germination was completed and a period of hot weather had been experienced, a count of the number of seedlings per square foot was made. This count proved definitely that peat was not as satisfactory for covering spruce seed as sand, since the former reduced germination somewhat and, presumably due to greater heat absorption by its black surface, increased mortality considerably. A satisfactory stand remained on the sand-covered plots, but not on those covered by peat. If the summer had been cool and moist, the peat might have given better results, but apparently sand is a safer material to use.

Cover	Species	Number seedlings per sq. ft.			Percent dead
		Germinated	Alive	Dead	
			July 29		
Peat	White spruce	58.0	6.3	51.7	89
	Black spruce	81.0	14.0	67.0	83
Sand	White spruce	84.0	54.3	29.7	35
	Black spruce	105.9	73.9	32.0	30

No. 137

February, 1938

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Earlier Returns from Thinned Red Pine

Will thinnings in young red pine bring the trees to merchantable size earlier than trees in unthinned stands and as a result appreciably lessen the length of time the owner must wait before financial returns can be realized? To answer this question, four sample plots thinned to spacings of 6x6 feet, 8x8 feet, 10x10 feet, and an unthinned plot were established on the Chippewa National Forest in 1927. The growth in diameter and volume during the ten-year period since thinning is shown in the table below.

Spacing	Number of trees per acre			Average diameter			Volume per acre		
	1927	1932	1937	1927	1932	1937	1927	1932	1937
					Inches			Cubic feet	
Unthinned	3,620	3,060	2,740	2.5	2.8	3.0	1,008	1,623	1,975
6x6	1,229	1,222	1,208	2.2	3.0	3.6	276	652	1,041
8x8	700	700	700	2.7	3.7	4.4	258	569	969
10x10	441	427	422	2.9	4.2	5.1	195	446	770

The unthinned plot, having the greater number of trees, has also the greater volume, but much of this is in small trees destined to die out before the stand reaches merchantable size. Both the 6x6 and 8x8 thinned plots produced more volume during the past five years than the control. The trees on thinned plots have grown from 72 to 106 percent more in diameter during the past ten years than the corresponding numbers of most rapidly growing trees on the unthinned plot.

Though the final answer to the question cannot be had for another ten years, should the present trend in growth continue, the thinned stands will be merchantable at least 10 years ahead of the natural stand. The most promising spacing is 8x8 feet because it allows rapid growth, yet contains enough stems to yield frequent commercial cuts in the future.

MAINTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

Water Tables and Survival

In planting reconnaissance in the Lake States, foresters usually consider :h factors as character of cover and soil texture in deciding which species and : classes are to be planted on a given site. Another factor, of great importance some cases, but sometimes not recognized, is the depth of the water table and : effect on soil moisture. Its range of fluctuation and depth in relation to ot habits of plants must also be considered.

In the spring of 1937 a plot established in Wisconsin by J. H. Stoeckeler l G. A. Limstrom on the Nicolet Forest showed marked variation in survival at : end of the first growing season due to difference in depth of the water table. e differences in survival, shown in the accompanying table, were accentuated be- ise of a severe local drought, precipitation for the period of May 1 to August 31 :lusive being less than 53 percent of normal for any of these four months.

pecies lanted*	Age class	Upland (Water table deeper than 6 feet)		Lowland (Water table at depth of 5 to 6 feet)	
		No. trees	Survival %	No. trees	Survival %
:k pine	1-0	661	29.2	339	76.8
" "	2-0	674	29.8	326	81.3
" "	1-1	693	33.2	307	82.4
l pine	2-0	692	14.5	308	64.3
" "	2-1	683	16.1	317	71.3
" "	2-2	636	44.9	364	84.9

ata based on 1000 trees planted for each species and age class. (10 replications f 100 trees.) Total, 6000 trees.

The entire plot was open in character, with a heavy sod cover; the soil on th portions of the plot was a loamy fine sand with a fine sand subsoil, and ffered only in the degree of podsolization.

Moisture samples were taken throughout the season in the 0-6, 6-12, and 12- inch zones. It was observed that there was little difference in available isture content in the top foot of soil in either area, but that there was gener- ly from 1 to 3 percent more available moisture in the 12-18 inch zone in the wland portion of the plot. There was enough capillary rise (about 4 feet) from e underlying water table to moisten this zone and, therefore, it could be con- dered as the upper part of the capillary fringe. (See back of this sheet.)

Although the difference in moisture content was not great, it was sufficient cause a startling increase in survival, especially in a season of subnormal infall.

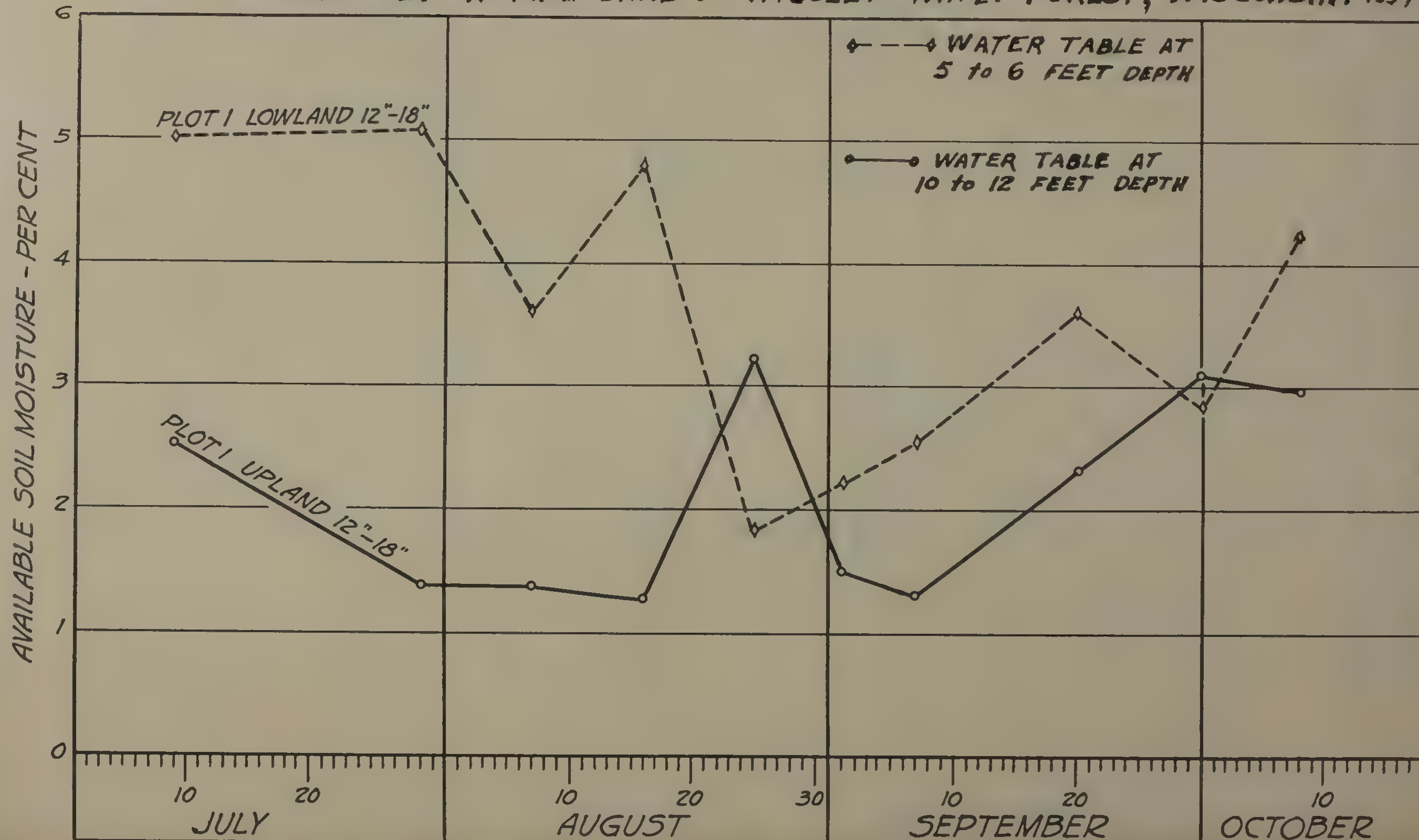
These tests, which are corroborated by direct seeding experiments conducted Ranger K. B. Pomeroy in this same vicinity, emphasize the need for considering pth to water table in selecting sites for planting.

In the spring of 1937, Pomeroy sowed jack pine in furrows with a mechanical eder and in the fall, counts showed an excellent stand of seedlings (often 20 or per yard of furrow) in the low swales where the water table was 4 to 5 feet low the surface, and almost a complete failure on the surrounding uplands where e water table was from 6 to 20 feet below the surface.

February, 1938

NTAINED BY THE U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

GRAPH SHOWING EFFECT OF SHALLOW WATER TABLE ON SOIL MOISTURE CONTENT IN THE 12 TO 18 INCH LEVEL IN A LOAMY FINE SAND SOIL UNDERLAIN BY A FINE SAND. NICOLET NAT'L. FOREST, WISCONSIN. 1937.



TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · FOREST SERVICE
No. 140

Deep Rooting and Plantation Survival

The need for planting large stock on sites subject to extreme drought conditions is now quite generally recognized. The reasons for the increased survival of large stock are, however, still a matter of conjecture, and often are attributed to one or two of many factors, all of which may contribute to higher survivals with the use of large planting stock.

For instance, larger stock having relatively thick bark and being better insulated against the heat of the sun invariably shows less damage resulting from direct heat injury, which was especially prevalent in 1936 in plantations on coarse, sandy soil.

An experimental planting established by J. H. Stoeckeler and G. A. Limstrom in the spring of 1937 on the Nicolet National Forest in Wisconsin indicates that one of the reasons why larger planting stock shows better survival at the end of the first growing season is its superior depth of rooting. (See graph on back of sheet.)

The inference is that those trees that had enough size, hence stored energy, to drive down roots rapidly into the more moist subsoil, were able to weather the severe local drought of 1937 much better than the smaller trees. The soil on the planting site ranged from a loamy fine sand to a sand to a depth of over 6 feet, and the area had no overhead cover. The water table was beyond reach of first-year rooting of conifers.

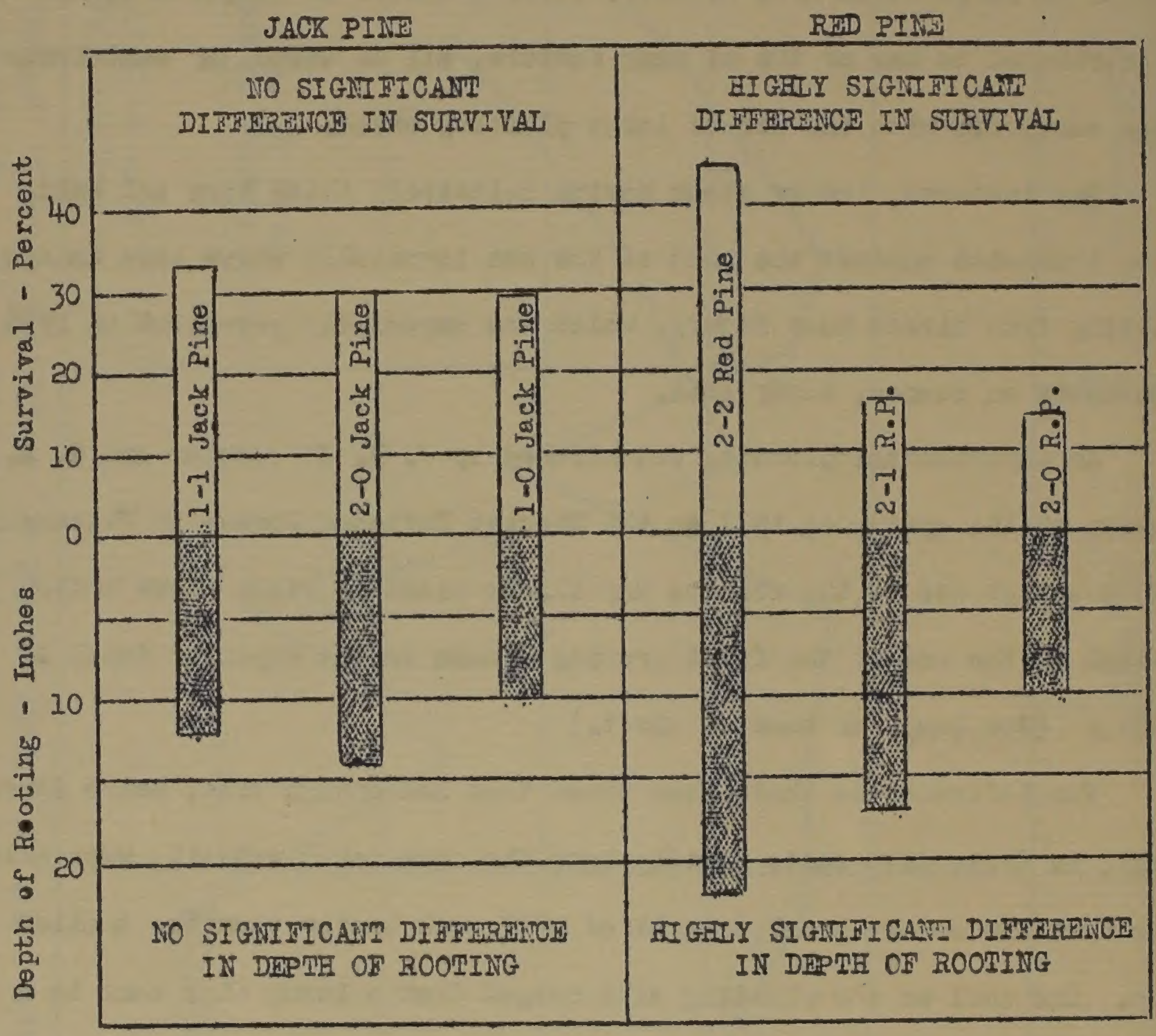
Although no jack pine planting stock was available that had a size comparable to the 2-2 red pine, it will be noted that in trees of approximately equal size, the jack pine was superior to the red pine in survival.

(Over)

February 1938

RELATIONSHIP OF SURVIVAL TO DEPTH OF ROOTING AT THE END OF THE FIRST GROWING SEASON ON A DROUGHTY LOAMY FINE SAND

Nicolet National Forest - Wis.



TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

When to Cut Jack Pine

There is a widespread belief that jack pine stands should be cut when they are 50 to 60 years old because of reduced growth rate and the encroachment of wood decay after such ages. However, according to studies made by the Lake States Forest Experiment Station on the Chippewa and Superior National Forests in Minnesota, it appears that jack pine stands on medium to good sites where there has been no fire injury need not be cut until they are 70 to 80 years old.

As illustrated by the following table, growth has continued at a good rate during the past 10 years in uncut stands in both localities. The growth compares very favorably with the 0.6 cord per acre per year which the yield table shows may be expected between 40 and 50 years in fully stocked stands on good sites. There is every reason to believe that it will continued to do so for at least another decade.

Forest	Age in 1926	Unpeeled volume in cords (to 3-inch top) 1926	1936	Average annual net growth (10 year period) Cords	Bd. ft.[o]	Site
Chippewa	55	40.5	46.0	0.55	434	Good
Superior	60	20.3	26.1	0.58	100	Medium

[o]The Chippewa stand was a saw timber stand, but that on the Superior was strictly a cordwood stand, hence the growth on a board-foot basis is considerably higher on the former stand.

On the other hand, other observations where jack pine stands have been injured by fire and are infected by decay, particularly on poor sites on the Huron National Forest in Michigan, indicate that such stands should be cut at ages not greater than 60 years in order to prevent excessive losses from rot and breakage.

No. 141 February 1938

TECHNICAL NOTES
LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · · · FOREST SERVICE
UNIVERSITY FARM ST. PAUL 1, MINNESOTA

THE GRAZED WOOD LOT - POTENTIAL FLOOD HAZARD AND LOW-GRADE PASTURE

Experiments carried on by the Upper Mississippi Valley Erosion Experiment Station at La Crosse, Wis., have demonstrated conclusively that when wooded slopes as steep as 25 to 35 percent are grazed, the farmer pays dearly for the forage in terms of a considerable loss of water.

Thus, in 1935 a grazed farmwoods lost 579 barrels of water per acre as runoff. An ungrazed forest on even steeper land lost only 10.3 barrels. The runoff from a moderately grazed bluegrass pasture with aspect, soil, and slope comparable to the two wooded tracts totaled 213 barrels of water or more than 20 times the amount from the ungrazed oak-hickory farmwoods.

Although the quantity of runoff varies greatly from one year to another because of differences in the total rainfall and number of intense rains, the proportions of runoff to total rainfall remain fairly constant. Especially is this true of the open pasture and grazed woods.

Between August 1 and 6, 1935, a series of rains caused some of the worst floods in the small rivers and large creeks of southwestern Wisconsin which have occurred during the last 30 years. A significant fact is that during this critical period of floods the runoff from an acre of ungrazed woods was only 1/47 of that from an acre of pastured forest.

When the ground is frozen, the effectiveness of grass or forest cover is not so striking but is still very distinct. This is shown by the fact that in March 1936, 14.7 barrels of water per acre from the ungrazed forest area--the entire year's loss, in fact--originated from snow melting on frozen ground. This was about 1/4 as much as from the grazed woods for the same period and half as much as from the open pasture.

Since March 24, 1936, every bit of precipitation falling on the loose, porous, litter-covered soil of the ungrazed wooded tract has soaked into the soil. During the same period the grazed farmwoods yielded runoff amounting to 540 barrels per acre, the open pasture 131 barrels.

Experience at the La Crosse Erosion Station has proven that most of the year's water loss occurs during a few heavy downpours. During the four years of record anywhere from 44 to 100 percent of the year's total runoff occurred during the three principal storms of that year.

From the standpoint of forage production, woods show up badly when compared with first-class bluegrass pastures. Roughly speaking, the thin, heavily shaded sod found under a forest stand on a 25- or 35-percent slope is incapable of yielding, even under ideal conditions, more than one-half the grass that can be expected from a good pasture. This fact is well illustrated by the figure on the reverse side of the sheet.

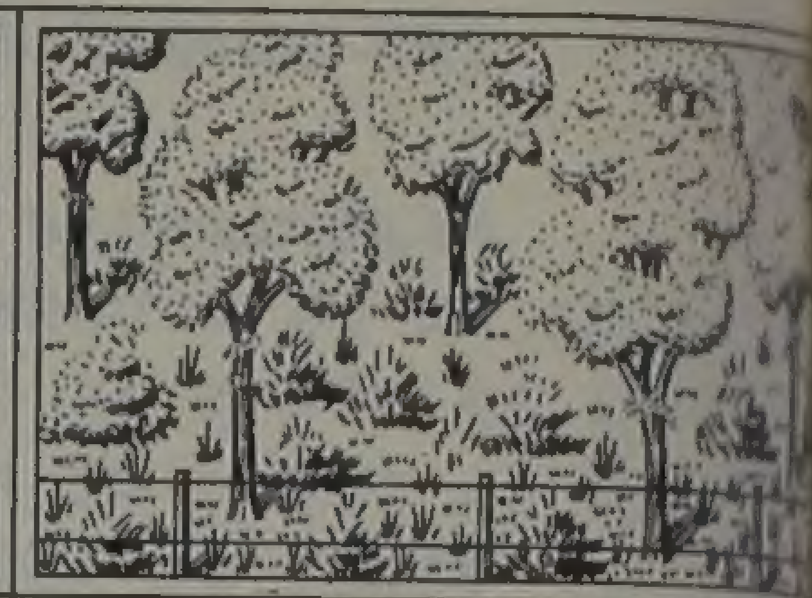
Grazed woods yield high runoff, add to flood dangers, and make poor pastures. Thus, from the standpoint of proper land use, steep slopes, especially those with rocky and easily eroded soil, should not be used for pasture but for the growth of trees instead.

MAINTAINED IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

EFFECT OF TYPE OF COVER AND CHARACTER OF LAND-USE UPON RUN-OFF FROM STEEP SLOPES

UPPER MISSISSIPPI VALLEY EROSION EXPERIMENT STATION

LA CROSSE ~ WIS.



	OPEN, MODERATELY-GRAZED PASTURE. (WATERSHED "G")	GRAZED WOODS ON NORTH SLOPE (WATERSHED "A")	UNGRAZED, UNBURNED WOOD ON NORTH SLOPE (WATERSHED
TOTAL RUNOFF FROM 37.91 INCHES OF PRECIPITATION. NO. OF 50-GAL. BBLS. PER ACRE.	213 BBLS. 1935	579 BBLS. 1935	10.3 BBLS. 1935
TOTAL RUNOFF FROM 27.75 INCHES OF PRECIPITATION. NO. OF 50-GAL. BBLS. PER ACRE.	49 BBLS. 1936	150 BBLS. 1936	14.7 BBLS. ENTIRELY FROM MELTING SNOW 1936
TOTAL RUNOFF FROM 27.92 INCHES OF PRECIPITATION. NO. OF 50-GAL. BBLS. PER ACRE.	10 BBLS. 1937	26 BBLS. 1937	NO RUNOFF 1937
TOTAL RUNOFF FROM 38.11 INCHES OF PRECIPITATION. NO. OF 50-GAL. BBLS. PER ACRE.	97 BBLS. 1938	427 BBLS. 1938	NO RUNOFF 1938
COW-DAYS OF GRAZING PER ACRE FOR A 5-MONTH SEASON.	141 DAYS FEED 1935	68 DAYS FEED 1935	
COW-DAYS OF GRAZING PER ACRE FOR A 5-MONTH SEASON.	143 DAYS FEED 1936	66 DAYS FEED 1936	
COW-DAYS OF GRAZING PER ACRE FOR A 5-MONTH SEASON.	157 DAYS FEED 1937	84 DAYS FEED 1937	
COW-DAYS OF GRAZING PER ACRE FOR A 5-MONTH SEASON.	130 DAYS FEED 1938	64 DAYS FEED 1938	

LEGEND

WATERSHED "G" - 5.85 ACRES DIVESTED OF ITS 2ND. GROWTH TIMBER IN 1932. SLOPE 25 TO 35%. GRAZED TO OPTIMUM CARRYING CAPACITY.

WATERSHED "A" - 2.67 ACRES WITH 2ND. GROWTH HARDWOODS. SLOPE 15 TO 28%. GRAZED TO OPTIMUM CARRYING CAPACITY.

WATERSHED "B" - 11.50 ACRES COVERED WITH 2ND. GROWTH HARDWOOD TIMBER. SLOPE 25 TO 50%. MAINTAINED IN AN UNGRAZED UNBURNED CONDITION.